Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

# Mineral Policy

## A Discussion Paper



Canada

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# Preface

The Canadian nonfuel mineral industry historically has been one of the mainstays of the country's economy. Although the industry experienced a relatively slow rate of growth through the 1970s compared to the buoyant period of the 1950s and 1960s, the value of basic mineral output in 1980 nevertheless amounted to $13.9 billion. When refined metal and other fabricated mineral products are added, the total value of output exceeded $31.4 billion. Moreover, the Canadian mineral sector is characterized by tremendous complexity and diversity in all its dimensions — geological, technological, structural and spatial. The nonfuel mineral sector produces at least 60 different minerals from 260 mines, 230 mills, 16 smelters and 15 refineries widely distributed across Canada. It generates the principal proportions of employment income in some 175 communities from British Columbia to Newfoundland, from southern Ontario to the far North.

More than 80 per cent of mineral production is sold to other countries — Canada is the world's largest mineral exporter. The more recent period of slow growth, therefore, was largely a reflection of the general economic slowdown that occurred throughout the Western industrialized world. Current forecasts indicate that the industry should fare relatively better through the 1980s than the 1974-80 period, though the high growth rates of the earlier decades will probably not be realized.

This discussion paper is being issued at a time of exceptionally low demand for most minerals. The Canadian minerals industry, like other industries in Canada, and like its counterparts throughout the world, is experiencing an extended and severe down-cycle in prices and profits. For some metals, analysts have noted that prices are at their lowest real levels in many years. The federal government is fully cognizant of the present situation and of the need for a policy environment that will help the industry to capture opportunities when markets improve. Despite recurrent highs and lows in the business cycle, the government believes that policies must be made for the longer term.

To ensure that this important segment of Canada's industrial base remains healthy and competitive — that it is able to contribute to the well-being of all Canadians to its maximum potential — my Department has developed a number of proposals that will be pursued during the 1980s.

By way of providing a context for these proposals, this Mineral Policy Discussion Paper has adopted *opportunity as the theme, private sector initiative with complementary government action as the philosophy, and maximization of returns to labour and capital — without compromising on social objectives — as the goal.*

Given the projected economic climate of the 1980s, and the need to protect the environment, assure worker health and safety and settle land claims equitably, the conclusion emerges that the greater opportunities involve improvements in the quality, together with selective increases in the physical quantity, of mineral development. These improvements in the quality of development will involve the achievement of social goals as well as higher levels of technical and economic efficiency.

The philosophy of private sector initiative with complementary government action implies that the federal government will follow a policy of no subsidization except in special circum-

stances (e.g. regional development if unemployed resources exist). Where initiatives call for action at the federal level, these will be effected by the establishment of the necessary programs and activities within appropriate federal departments and agencies. Areas where direct federal efforts are particularly vital include the removal of existing imperfections (structural impediments such as barriers to entry for junior mining); reduction of trade barriers in the international market; the collection, assessment and dissemination of geological, technical and economic information; provision of adequate research and development where the private sector does not meet this need; correction, where necessary, of divergences between private and social costs of mineral development; realization of spin-off benefits from mineral development such as mineral machinery and equipment; management of mineral resources on Canada Lands; provision of necessary infrastructure; enhancement of the quality of working life; and maintenance of an appropriate taxation and investment climate.

The federal government also recognizes the critical role played by the provincial governments, as owners and custodians of mineral resources within their boundaries. In addition to defining possible federal initiatives and a complementary federal role in assisting the provinces in managing their mineral resources, the Mineral Policy Discussion Paper also outlines possible areas where joint federal-provincial actions may be appropriate. All of these initiatives will be the subject of close consultations with the provinces. In this way, we can best assure close coordination of efforts between both levels of government in order to maintain a healthy mineral industry that will realize the full potential of new opportunities identified in this paper. Moreover, the process of consultation will also involve industry and labour.

As noted in the document on *Economic Development for Canada in the 1980s* released with the November 12, 1981 Budget, the Mineral Policy paper is one of a series of reports on the resource sectors of the Canadian economy. As such, it reflects the themes and priorities identified in the economic development document.

Canada's mineral wealth has served the people of this country well, but the resource itself and the complex factors that govern its use cannot be taken for granted; they must be re-examined and better understood, and more effectively nurtured where necessary and possible. This Discussion Paper is offered as a starting point for this process. In the coming weeks and months, I look forward to reactions and suggestions from all segments of the mining and mineral-processing community in this country.

Judy Erola

The Honourable Judy Erola
Minister of State (Mines)

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# Summary and Statement of Initiatives

The government's assessment of the opportunities and constraints facing the Canadian mineral industry in the 1980s was conducted within the context of three principal objectives — strengthening the resource base on which the industry rests, ensuring the adequacy of research activities needed to support development of the resource, and furthering the development of markets for the resource. To these ends, detailed studies were carried out on the factors and issues impinging on the industry in more than a dozen broad areas:

Resource Adequacy
Security of Supply
Competitive Position
Taxation
Foreign Ownership
The Junior Mining Industry
Infrastructure
Northern and Regional Development
Employment and Quality of Working Life
Environment
Further Processing
The Mineral Machinery and Equipment Industry
Mineral Science and Technology
International Marketing of Minerals
Investment Climate

As the studies progressed, it became evident that six areas in particular warranted priority attention, both in terms of the needs that exist and the degree to which these needs could be influenced by specific initiatives and action by the federal government. These areas are:

The Junior Mining Industry
The Mineral Machinery and Equipment Industry
Mineral Science and Technology
Employment and Quality of Working Life
International Marketing of Minerals
Investment Climate

It must be emphasized that the setting of priorities in these areas does not mean that problems in other areas can be minimized or overlooked — all issues for which initiatives have been established are important, and some are crucially so.

## The Junior Mining Industry

Historically, the junior mining industry — which consists of small, independent exploration and development enterprises, largely Canadian owned and controlled — has been responsible for many mineral discoveries that have led to major developments. Unfortunately, this segment of the mineral sector has fallen on hard times in recent years — technological changes have increased the cost of exploration, taxation changes have reduced the after-tax profitability of new mine investment by junior mining companies, and securities legislation changes have made it more difficult for these companies to raise equity capital.

Despite all this, junior mining is still more productive in finding new deposits than the senior component of the sector. While junior mining's share of expenditures on exploration fell from about 50 per cent in 1969 to 10 per cent in 1979, this segment of the mineral industry was nevertheless responsible for 40 per cent of all new discoveries in the 1970s.

It is essential that the decline of the junior mining industry be arrested and reversed. The solution to the problems, at the federal level, involves action in four policy areas: taxation, dissemination of geological information, encouragement of custom milling, and encouragement of research and development in exploration technology.

### Policy Initiatives

*To strengthen the junior mining component of the mineral sector so that its major contribution to increased mineral discoveries will continue, the federal government intends to consider measures to*:

- Enhance incentives to promote junior mines;
- Improve the quality of geoscientific information and technical data, which are filed by private industry with governments and eventually made available to the public;
- Improve filing requirements and standardize confidentiality periods for geoscientific information among federal and provincial jurisdictions, and, thereby, reduce the paper burden on industry;
- Support custom milling for small operators; and
- Encourage research and development (R&D) in exploration technology appropriate for use by small operators.

## The Mineral Machinery and Equipment Industry

The size of the Canadian mineral machinery industry is disproportionately small compared to the size of the Canadian mineral industry, which is currently the world's third largest. Thus, the performance of the equipment industry has fallen far short of what could have been expected. Canada has a low degree of self-sufficiency in the production of mineral equipment, and value added in the industry is low due to the high foreign content of production.

Also, the Canadian equipment industry has specialized in the lower end of the technology spectrum, depriving Canadians of highly skilled and well paying employment. Domination of the industry by subsidiaries of foreign firms and other structural problems has produced a situation whereby new technology developed in Canada is often passed on to the foreign parent company for design and patent of related equipment, which is then exported to other countries including Canada. The lack of "turn-key" capability — assuming total responsibility for a project, from design to completion — has severely limited market opportunities for the domestic industry.

Significant shifts in the demand for specific types of mining and mineral processing equipment are expected to occur in the 1980s. Unfortunately, the areas of high growth potential are precisely those in which Canada's manufacturing capability is limited. To make the most of the possibilities for industrial diversification and development offered by Canada's large mineral industry, a number of policy initiatives are needed.

### Policy Initiatives

*To maximize the economic spinoffs from the development of Canada's mineral wealth through the promotion of a dynamic minerals machinery and equipment industry, the federal government intends to consider measures to:*

- Encourage domestic procurement for future private sector mineral developments within the context of the government's regional and industrial benefits policy;
- Encourage enhanced product coverage and export mandates, as well as indigenous R&D and market development, and encourage rationalization of fragmented assembly-type operations, in the context of the government's overall strategy for the machinery and equipment sector;
- Foster an expansion in Canadian engineering, project management and construction capability to the point where domestic and international turn-key projects can be managed;
- Strengthen the links between mining companies, equipment suppliers and the engineering, project management and construction companies;
- Formulate an export promotion strategy for this industry to target existing programs more effectively; and
- Enhance R&D expertise and research efforts by the Canada Centre for Mineral and Energy Technology (CANMET) — a branch of the Department of Energy, Mines and Resources (EMR) — to complement the R&D efforts of Canadian equipment producers.

## Mineral Science and Technology

The federal government provides or facilitates a wide range of scientific and technological programs and services in support of mineral development. The purpose of these activities is to enhance geoscientific knowledge and to develop and diffuse technologies used in the various stages of mineral processing. The encouragement of mineral research and development at the federal level has contributed in great measure to the growth of the mineral industry in this country. Canada's competitive edge in mineral technology, compared to other mineral-exporting countries, has offset to a degree its competitive disadvantage in terms of higher wage costs and lower ore grades.

To strengthen this significant contribution to the growth of the mineral industry and to the economy as a whole, as well as to the quality of working life, new or refocused science and technology (S&T) is required in several areas. Also, a number of institutional innovations are needed to enhance and strengthen the diffusion, efficiency and value of both public and private mineral S&T.

### Policy Initiatives

*To augment its mineral science and technology capability, and to promote innovation in industry and improve the transfer and diffusion of industrial technology, the federal government intends to consider measures such as:*

- Development of a standardized and consolidated national geoscience data bank;
- Formulation of regulations for the release of specific earth science information acquired by the private sector to governments and the public;
- Promotion of the development of the next generation of exploration technologies (e.g. mineral discovery at depth);
- Increased R&D on Canadian mineral deposit types to gain and improve understanding of their origin and thus lead to more efficient mineral exploration efforts, particularly in areas of high mineral potential;

- Promotion of the development, diffusion and use of energy-efficient, environmentally sound mining and mineral processing technologies to enhance the economic viability of subeconomic deposits (e.g. complex ores);
- Enhanced exploration and R&D for chromium and manganese, which are considered the more vulnerable strategic minerals;
- Improvement in the utilization of available basic and applied knowledge to promote demonstration projects, subject to appropriate criteria, in order to reinforce technology transfer;
- Development of a battery of measures, comprising technology monitoring and technological intelligence, to facilitate and expedite the application of new technologies in order to improve efficiency and productive capacity across the sector;
- Increased government R&D to improve health and safety in mineral operations and to control hazardous byproducts from mines and mineral processing facilities;
- Establishment of a small group of experts at EMR to advise on health and safety issues; and
- As part of the government's policy to reduce regional disparities, increased support for the provision of geological information in disadvantaged regions either through the programs of EMR or through federal-provincial mineral agreements funded by the Department of Regional Industrial Expansion (DRIE).

## Employment and Quality of Working Life

There is growing concern in the mineral sector over production bottlenecks that are anticipated in the 1980s due to shortages of skilled labour. Since this problem is currently being addressed on a national level by the Canada Employment and Immigration Commission, no government programs geared specifically to the mineral industry are proposed. However, the private sector is urged to exert more effort to attract and retain skilled workers, including measures to increase recruitment from nontraditional sources such as women and native people.

Health and safety in the workplace has also emerged as a major issue in the mining industry, where the injury and fatality rates are among the highest in the country. A number of federal measures will be undertaken to help alleviate this serious problem.

The issue of pensions in the mining sector is a matter of increasing concern in labour negotiations. Although pensions in mining are better than in many industries, there are nevertheless problems with vesting and portability which, coupled with the high attrition rate in the sector, means that many workers in the industry will never be eligible for a pension. This problem can be adequately dealt with only through the current federal-provincial discussions on pension reform. In the interim, the mineral industry is urged to continue to improve the standards and effectiveness of privately sponsored plans.

### Policy Initiatives

*To maximize economic returns and social benefits from mineral development, and to ensure an adequate supply of skilled labour, the federal government intends to consider measures to:*

- Encourage the establishment of terms and conditions for native and female employment on mineral projects on Canada Lands or in the provinces where the federal government has leverage, in the context of the Labour Market Task Force's Report and other government initiatives;
- Develop health and safety model standards representing state-of-the-art applications of regulations and technology, as general guidelines and for application in areas under federal jurisdiction;

- Support the training of key disciplines where manpower bottlenecks are anticipated, in a manner consistent with the recommendations of the Labour Market Task Force and other forthcoming initiatives;
- Streamline regulatory responsibility for health and safety at the federal level;
- Consider measures to increase research and development in the field of health and safety, particularly through the work program of CANMET; and
- Deal with the problem of pensions, in terms of coverage, vesting, portability and survivor benefits, as part of the government's current pension review.

## International Marketing of Minerals

The Canadian mineral industry has developed and thrived largely as a producer for foreign markets. Nevertheless, it faces a number of persistent marketing difficulties, the most important of which has been the failure of Canadian semifabricated and manufactured mineral products to penetrate major foreign markets to any appreciable extent. The major obstacles are tariffs that escalate with the degree of processing, as well as a number of nontariff barriers.

A more recent development that could also affect the Canadian mineral industry has been the evolution of a variety of mineral programs and policies in Japan, West Germany, France and the United States, designed to increase their security of supply for minerals. These procurement strategies have not yet seriously affected Canada, but they have the potential to become harmful if the countries involved were to subsidize production of minerals in countries that compete with Canada. At the same time, this development presents opportunities for Canada as a secure supplier of certain minerals.

Canada has always favoured participation in international commodity arrangements that recognize the rights and interests of both producers and consumers. There is evidence, however, that the present practice of maintaining a cautious, and somewhat negative, attitude towards producer associations should be reconsidered in the case of producer organizations whose main purpose is to share data and market intelligence, rather than engage in cartel-like actions.

There is some concern over the possible effects of potential mining of deep-sea nodules on Canada's land-based nickel industry. During negotiations on the *Law of the Sea Treaty*, Canada has defended the interests of its land-based nickel industry. While the next session of the Conference is slated to be the last, the Canadian delegation will continue to advocate the maintenance of fair competitive practices and a liberal trading regime.

### Policy Initiatives

*To expand markets abroad for Canadian minerals, particularly for semifabricated and manufactured mineral-based products, the federal government, in the context of its trade and foreign relations strategy, intends to:*

- Continue to seek international agreement to reduce or eliminate tariff and nontariff trade barriers through multilateral negotiations, and study the possible benefits of pursuing bilateral negotiations on a selective basis;
- Give consideration to the interests of Canada's trading partners in gaining secure supplies of minerals, and to the option of joining producer associations whose main purpose is to share data, information and market intelligence;
- Continue to advocate the inclusion in the *Law of the Sea Treaty* of a comprehensive antisubsidization clause for seabed nickel and a free market access clause for land-based nickel; and
- Consider selective use of potash as a commodity form of foreign aid.

## Investment Climate

An attractive investment climate is essential to the health and vigour of Canada's mineral industry. In this regard, a number of areas have been identified where appropriate federal action might be helpful. Some of the more important of these relate to: the impact of major policies in other areas of government activity on the mineral industry's international competitiveness; the effect of native land-claim settlements; infrastructure needs in new and remote mining regions; the potential for further development of the mineral semifabricating and manufacturing industry; and better coordination of mineral policies at the federal level.

### Policy Initiatives

*To maintain an attractive investment environment for mineral exploration and development, the federal government intends to*:

- Maintain stability in taxation and the investment climate;
- Negotiate the settlement of native land claims;
- Meet new infrastructure requirements to promote mineral developments on a cost-recovery basis, but consider subsidization where there are identifiable net social benefits; and
- Maintain the present policy environment for smelting and refining, and focus new initiatives on semifabrication and mineral-based manufacturing.

# Background

## Introduction

This Discussion Paper assesses the current and expected performance of the nonfuel mineral industry[1], evaluates the effect of existing government policies on that performance, and suggests policy alternatives for enhancing the contribution of the industry to the general welfare of all Canadians. However, with some notable exceptions, the paper does not deal with policies and programs in a very specific and detailed way. Rather, it seeks to provide a global perspective, a decision-making framework and an analytical approach to the problems of the sector.

The Discussion Paper, as noted in the November 12, 1981 Budget, is one of a series of such reports on the various resource sectors including forestry, agriculture and fisheries.

Like the other resource sector reports, the mineral policy paper is concerned with the assessment of three aspects of the exploitation of these primary commodities: the resource base, research and development, and international marketing of minerals. These aspects and their various subcomponents, as well as the issue of mineral-based industrial diversification, are considered in subsequent chapters of this paper.

## The Objectives

In the context of current preoccupations, this paper could have placed equal emphasis on the objectives of security, fairness and opportunity. Instead, it is the goal of opportunity that is stressed, for reasons that will be explored below. Fairness is a relevant but subsidiary consideration because, relative to the oil and gas sector, for example, mining revenues are both smaller and more equitably distributed among the provinces and regions. Security of supply, although also a clearly important objective, is one that Canada has already largely achieved in the mining sector. Thus, it is opportunity that commands most of our attention in this paper.

"Opportunity" concerns the ability of the mineral industry to provide remunerative employment, and an adequate return on capital, without compromising the government's — and the public's — stated social goals with respect to protection of the environment, the health and safety of workers, the land claims of native people and so forth. A major conclusion of the paper with respect to the resource base, the level of technology and international markets is that there have been and will continue to be opportunities to develop mines and processing facilities that are able to bear all private and social costs while assuring an adequate return on investment. However, such opportunities will probably arise less frequently than in the resource boom of the 1950s and 1960s.

The paper questions the wisdom of fixed targets, e.g. maintenance of Canada's share of the international metal market, that would involve a commitment by the government to assure

[1] The Canadian mineral industry encompasses all those activities carried out by enterprises and individuals involved in the exploration for and discovery of, extraction, processing (milling, smelting, refining) and marketing of mineral products. A variety of activities that are auxiliary to mineral extraction and processing also should be included in the sector (basic resource assessment, geological mapping, research and development activities, and various services provided to the mineral sector such as consulting services in engineering and construction). Additional economic activities — the fabrication of mineral products beyond the refined stage, and the production of mineral machinery and equipment — are closely linked with the minerals sector, but traditionally are considered as branches of manufacturing.

their achievement. Any shortfall from such targets would create considerable pressure for one or a combination of (a) subsidies, (b) tax expenditures, (c) lower standards on social goals, (d) lower wage levels or inferior working conditions for employees relative to their counterparts in other sectors, and (e) subsidization of capital employed in mining operations by nonmineral activities. The paper does not reject the proposition that Canada's competitive position will permit the maintenance of market shares or even increases for some commodities, but it points to the danger of attempting to force this result rather than allowing market criteria, *including both social and private costs*, to guide the pattern and level of development and production in the mineral industry.

Since the mineral industry as a whole has been, and probably will continue to be, competitive in international markets, the paper suggests that governments facilitate adjustment rather than slow its pace when specific problems arise. The closing of mines is inevitable and, although the social costs of such events must always be considered before allowing a project to proceed, they are not catastrophic occurrences in an environment where labour and capital have other opportunities. It is also inevitable that most mineral commodities will experience cyclical, rather than long-term problems, and in some such cases temporary assistance from government can be a worthwhile measure.

The basically noninterventionist or laissez-faire approach of the paper should not be interpreted as signalling the end of any government role or, specifically, a federal role in this sector. Such a role is essential in (a) removing the imperfections of market structure that exist at the present time; (b) counteracting the interventions that occur in the international arena; (c) providing public goods such as the gathering, assessment and dissemination of economic and geological information; (d) providing R&D support where the private sector is unable to fulfill this role (e.g. for policy development); (e) managing mineral resources in Canada Lands; (f) correcting divergences between private and social costs; and (g) realizing the spin-off benefits from mineral development, e.g. mineral machinery and equipment. Each of these items poses major challenges and also opportunities for public policy.

## The Role of the Mineral Industry in the Canadian Economy

Canadian economic policy has been dominated by the view that growth in the absolute size of the economy, as measured by the Gross National Product (GNP), was the relevant policy target. It was assumed that growth in the economy as a whole would ultimately lead to the capture of economies of scale, and therefore, increases in GNP per capita as well as impressive gains in GNP per se. The mineral industry was not immune from this view of the world. There are frequent references in past policy review exercises to the contribution of this sector to employment generation, without due consideration being given to the fact that the maximization of output per unit of labour input is the key to higher living standards. Again, one can find numerous references to the large foreign exchange earnings of the industry without any discussion of whether these could have been obtained with more or less resources. The mineral industry, as already explained, was not unique as far as this concept of the Canadian economy is concerned and, therefore, the policy environment was dominated by relatively permissive policies on immigration, foreign investment and tax expenditures.

A shift in these views occurred in the 1970s when a greater concern with the quality rather than the quantity of development was translated into policy through tax reform, stricter environmental requirements, the tackling of land claims issues and so forth. Unfortunately, the international economic environment became unfavourable at approximately the same time, and this constrained the implementation of public policy proposals in these areas. Therefore, this paper seeks to steer a middle course between the unabashed growthmanship of the 1950s and

1960s and the limits to growth philosophy of the middle 1970s. In fact, there is not much choice since the growth rates of the international economy are unlikely to recover to their pre-1974 levels, and concern with social issues represents a legitimate aspect of the public's aspirations for an improved quality of life.

As already noted, an obligatory aspect of sectoral policy reviews is a section on the importance of the industry in question relative to the Canadian economy. However, size is not a very effective argument for special treatment, and the usual data presented here are for informational purposes only. Subsequently, there will be a discussion of some of the unique features of the industry that do have implications for analytical and policy purposes.

The importance of the mineral sector in the Canadian economy are summarized as follows:

- *Contribution to GNP.* The gross value of minerals output up to and including the refined metal stage was $31.4 billion in 1980. (This includes iron and steel as well as metallic, nonmetallic and structural mineral products.) In terms of "value added", the sector contributed 4.7 per cent of total GNP in 1978.
- *Employment.* In 1980 the mineral sector employed some 274 000 persons directly in mining and processing to the same refined metal stage. It also employs substantial numbers in mineral service activities as well as mining machinery and equipment and metal fabrication.
- *Value Added per Employee.* In 1978 the average value added per employee exceeded that of manufacturing:

| Mineral Products Sector to Refined Metal Stage | Total Manufacturing |
|---|---|
| $42 000 per employee | $31 000 per employee |

- *Investment.* Investment in the mineral industry as a proportion of total investment in the Canadian economy (6.9 per cent)[1] is higher than similar ratios for contribution to GNP and employment as a proportion of the labour force.
- *Foreign Exchange Earnings.* The sector is generally responsible for 15 to 20 per cent of the value of Canada's exports of goods and services depending on the year chosen. In 1979, exports of metal ores, concentrates and scrap (including radioactive ores), nonmetallic minerals (including potash), nonferrous metals, and iron and steel amounted to $11.1 billion. Imports of these same categories were $5.1 billion, for a positive net trade balance of $6.0 billion. Total Canadian merchandise exports were $65.5 billion in 1979.
- *Tax Revenues.* The mineral sector's contribution to federal and provincial tax revenues is small relative to the petroleum sector. Total taxes (including mining taxes and royalties) in the oil and gas sector were $4089.1 million in 1978, compared to $588.5 million for nonfuel minerals. These issues are discussed in a later chapter; but it is worthwhile to note that mineral revenues are more dispersed across the country, and therefore, cause less regional inequality which result in lower equalization payments.
- *Transportation.* Minerals are important users of Canada's transportation systems. They constitute about 60 per cent of all railway freight (by weight), one half of all cargoes loaded at Canadian seaports and about one half of Seaway and Great Lakes shipping traffic. In this way, minerals contribute substantially to covering the overhead costs of the transportation systems. This fact explains the extreme sensitivity of the industry to the issue of cross-subsidization because of the Crows Nest Pass Grain Rates, rate-

[1] Includes all minerals except oil and gas, i.e. primary metals (including iron and steel), nonmetallic mineral products and coal.

setting procedures of the railroads in conjunction with the Canadian Transport Commission (CTC) and regulatory changes that will be very costly, e.g. transport of hazardous products.

There are a number of other factors that illustrate the character rather than the importance of the industry.

- *Risk*. The inherent riskiness of the whole exploration and discovery process is well known. Less well known is the fact that the riskiness of exploration for nonfuel minerals is considerably greater than for oil and gas. In the case of the former, perhaps only one hole out of 1000 drilled may result in a significant mineral find while for the latter the ratio may be one in seven. The extraction, smelting and refining stages of mineral exploitation are inherently not more risky than manufacturing, although increased instability of output prices in the 1970s may have made this conclusion of the Carter Commission obsolete. The risky exploration phase has been dominated by the Canadian owned junior mines, and their problems are discussed in detail later on in the paper. Obviously, the riskiness of the mineral exploration effort can be reduced by pooling such risks through joint ventures. Moreover, for large firms, the riskiness of exploration is reduced because of their financial ability to diversify and use the tax system to advantage.
- *Energy Intensity*. The mineral industry is energy-intensive, especially at the smelting and refining stages. As a proportion of direct operating costs, energy makes up 35 to 45 per cent for aluminum, 30 to 35 per cent for zinc, and 20 to 25 per cent for copper.
- *Capital Intensity*. The sector is capital intensive especially at the smelting and refining stages. As a result of recent technological developments in mineral extraction and metallurgy (necessitated in some cases by lower ore grades) the amount of capital employed per worker has, on average, increased greatly, in both mining and smelting. Such technical changes have engendered economies of scale both in terms of capital cost and operating costs so that minimum efficient scale for mines, concentrators and smelters is generally very large.
- *Regional, Frontier and Northern Development*. The mineral sector generates the principal proportions of employment income in many mining communities in northern Manitoba, Ontario, Québec, Saskatchewan and British Columbia, as well as Labrador, the Northwest Territories and the Yukon. Some 175 communities are dependent upon mining as the major economic base and source of employment income. The sector continues to play a significant role in the development of frontier regions of the country. This feature of the industry leads to intense debates over adjustment policies, subsidization of infrastructure, and development of the North for sovereignty and other noneconomic reasons.
- *Concentration*. The Canadian mineral industry is heavily concentrated. It must be emphasized, however, that because most mineral markets are international, industrial structures that often appear to be "oligopolistic" domestically are, in fact, more competitive in the relevant context of the world market. International mineral markets have generally been becoming *more* competitive in the post-war period.

Within Canada, there were in 1981 more than 1100 mining companies listed for trading on Canadian stock exchanges. But less than 2 per cent of all incorporated mine enterprises generally pay dividends in any year. On the other hand, some mine enterprises are particularly large and may be vertically integrated (from mine-mouth to final products), horizontally integrated (including a number of mines and/or smelting operations for one or a number of minerals) and diversified out of the nonfuel mineral sector as well. A listing of the larger minerals enterprises operating in Canada is presented in Table 1.

**Table 1. Mine output of major producers as a percentage of total production of selected metals; total metal content of all concentrates produced in Canada, by metal, by corporate group (1980)**

| Producing company | Corporate group | Copper | Nickel | Lead | Zinc | Molybdenum | Gold | Silver |
|---|---|---|---|---|---|---|---|---|
| | | | | (%) | | | | |
| Inco Ltd. | Group | 16 | 85 | – | – | – | 3 | 4 |
| Noranda Mines Ltd. | Group | 20 | – | 17 | 27 | 54 | 16 | 26 |
| McIntyre-Falconbridge | Group | 5 | 15 | 1 | 3 | – | 9 | 5 |
| Kidd Creek Mines Ltd. | Single company | 9 | – | 1 | 19 | – | – | 21 |
| Cominco Ltd. | Group | – | – | 46 | 21 | – | 7 | 12 |
| Cyprus Anvil Mining Corp. | Single company | – | – | 27 | 9 | – | 1 | 7 |
| Hudson Bay Mining & Smelting Co. Ltd. | Group | 6 | – | – | 3 | – | 4 | 2 |
| Dome Mines Ltd. | Group | – | – | – | – | – | 21 | – |
| Lake Shore Mines | Group | – | – | – | – | – | 9 | – |
| Camflo Mines Ltd. | Single company | – | – | – | – | – | 3 | – |
| Total, major producers | | 56 | 100 | 92 | 82 | 54 | 73 | 77 |
| Other companies | | 44 | nil | 8 | 18 | 46 | 27 | 23 |
| Total | | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | | | (thousand tonnes) | | | | (tonnes) | |
| Total metal content of concentrates, all producers | | 708 | 195 | 274 | 895 | 12 | 48 | 1037 |
| Canadian production as a percentage of world production* (%) | | 9.1 | 24.4 | 8.3 | 17.0 | 11.3 | 4.0 | 9.6 |

SOURCE: E. Urquhart, *The Canadian Non-Ferrous Metals Industry: An Industrial Organization Study* (updated).
* Preliminary 1980 figures.

In addition to these economic ratios, there are some more fundamental characteristics of the industry that bear mentioning. These include: (a) the diversity of the industry, (b) the instability of product prices, (c) the international character of the industry (discussed in the following section), and (d) the provincial ownership of most mineral resources.

The nonfuel mineral sector produces some 60 different minerals from 260 mines, 230 mills, 16 smelters and 15 refineries. Not surprisingly, the sector is characterized by tremendous complexity and diversity in all its dimensions: geological, technological, structural and spatial.

The great diversity of the mineral sector raises the obvious issue about the advisability of proceeding with mineral policy on the sectoral as compared to a commodity-specific basis. However, there are also some common characteristics that tilt the argument in the other direction. These include the already mentioned similarities with respect to capital intensity, energy intensity, riskiness of the exploration phase, reliance on the international markets and constitutional provisions. Therefore, a global view of mineral policy can be justified, although there are particular minerals and metals where a commodity-specific strategy is more appropriate.

Possible examples include: (a) aluminum, although its substitutability with copper suggests inclusion in this paper; (b) iron ore, which has many unique features and problems (a separate paper is being prepared on this commodity); (c) asbestos, where health and safety concerns dominate other considerations; and (d) structural materials and aggregates, which rely on local markets. In general, the federal government has pursued mineral policies on the global and commodity-specific bases because of the diversity.

The instability of mineral markets, reflected in large price swings, will be discussed in greater detail in the international chapter of this paper. However, it is worthwhile to note that the available evidence indicates greater volatility in the 1970s than in earlier periods. The "conventional wisdom" in the mineral industry suggests that instability is favourable to Canada because of the greater flexibility of our industry with respect to production and investment plans. However, there may be offsetting costs in terms of maintaining a stable labour force. In addition, the increased instability of the 1970s probably has lowered the level of investment expenditures because of increased price uncertainty. It also may have encouraged some diversification into other lines of activity such as oil and gas (less cyclical) or forestry (different cyclical pattern). In any case, the two following approaches to this problem have been pursued in the past: (a) international action to stabilize mineral markets; and (b) domestic policies to deal with the effects of instability on investment, employment and output.

## The International Context of the Canadian Mineral Industry in the 1980s

The most important characteristic of the Canadian mineral industry is its international character and, specifically, the reliance on foreign markets. In 1980, approximately 80 per cent of the value of mineral production was exported. Of course, there was great diversity among minerals with regard to this ratio, but the domestic market is of primary importance only in the case of low-value, high-bulk commodities such as cement. To be sure, Canada's trade is heavily concentrated in terms of geography, with 34 per cent of the value of ores and concentrates going to the United States, 27 per cent to the European Economic Community (EEC), and 18 per cent to Japan. For refined metal, the reliance on the U.S. market is even more pronounced, with the figures being 60, 20 and 4 per cent respectively. Nevertheless, with the reduced importance of producer pricing, and the increased importance of lesser developed countries (LDCs) as markets for and suppliers of minerals and metals, the international character of the industry will only increase.

Given that the growth rate of industrial production is the major determinant of the growth of metal demand, it is not surprising that the 1950s, 1960s and early 1970s were looked upon as a golden age for the Canadian mineral industry. The effect of rapid economic growth was reinforced by the increasing mineral use per dollar output in some of Canada's major markets. For example, in the case of Japan, tonnes of metal consumption per million constant dollars of Gross Domestic Product (GDP) for copper, zinc and nickel increased from 1.32, 1.37 and 0.15 in 1955 to 2.41, 1.64 and 0.23, respectively, in 1973. When the downturn came after 1974, there was a search for causes of the decline which focused on federal and provincial tax reform, environmental legislation, and a more hostile policy setting in general, but the overwhelming evidence points to a slower rate of growth in the Organization for Economic Cooperation and Development (OECD) countries as the major factor.

Not surprisingly, there is intense speculation at the present time over the probability of the 1980s being more like the 1960s rather than the post-1974 era. (Indeed there is a more fundamental debate on whether the 1974-80 period represents the norm for industrialized countries or whether 1960-73 gives a better picture of average expected performance.) Almost all forecasts for the OECD countries show a growth rate for GNP in the 1980s which, although moderately better than for 1973-79, is well below the average performance of 1960-73. For exam-

ple, GDP in the industrial market economies is expected to grow at an annual average rate of 3.2 per cent in the 1980s. This is a little better than the average 1973-79 rate of 2.5 per cent, but compares unfavourably with the 4.9 per cent rate of 1960-73.

In the 1980s, demand for mineral commodities is expected to increase at rates below the 1960-73 period. Thus, for aluminum, the annual average growth rate for the 1980s is forecast to be 4.0 per cent or less than half of the 1960-73 period; for lead 2.5 per cent or one half; for copper, nickel and zinc, the figures are 2.5, 3.8 and 2.8 per cent respectively, or a little over one half of the earlier period. These declines are fairly dramatic, but the growth rates for the 1980s are projected to exceed the slow growth since 1974 as the chapter on *International Marketing of Minerals* indicates.

## The Challenges of the 1980s and 1990s

While slow growth of industrial demand in the OECD countries has been a principal factor in reduced demand for Canadian minerals, and a recovery to 1960-73 growth rates is not forecast for most minerals in the 1980s, the future is not entirely bleak. In spite of this smaller aggregate market expansion, there still will be attractive opportunities for the Canadian mining industry if the industry can maintain or improve its competitive position. Moreover, a marketing strategy directed toward the rapidly growing metal demand in the higher-income LDCs, coupled with technological advances, can produce considerable payoffs. Therefore, emphasis on the quality and structure of growth in the mineral sector, rather than just the quantity of growth, presents a major opportunity.

Slow growth in global mineral consumption is not a disaster for the Canadian mineral industry, nor is lower growth in the volume of our mineral output a catastrophic event if production is carried on with efficient, environmentally sound methods that bring adequate returns to invested capital and provide good working conditions for employees. The belief that Canada is a veritable treasure house of mineral wealth has, on occasion, pushed development beyond what could be justified by a consideration of all private and social costs. However, it is also true that there will be a number of opportunities as the examination of the resource base, international markets and linkage industries suggests.

Capturing these opportunities implies that the following major challenges of the 1980s (and 1990s) will be successfully met:

- *Technological challenges*
  - (a) Innovating new metallurgical technologies for extracting minerals from low-grade, complex or new ores;
  - (b) Innovating new environmentally sound, energy-saving technologies; and
  - (c) Innovating improved geological exploration techniques that are able to discover mineral deposits at depth.
- *Logistic challenges*
  - (a) Discovering and developing commercially profitable mineral deposits;
  - (b) Constructing productive capacity and infrastructure for mining-milling-smelting-refining projects in isolated areas; and
  - (c) Investing, both retrofit and new, in capital equipment that embodies the latest technology from worker health and safety standpoints
- *Institutional challenges*
  - (a) Arresting and reversing the continuing relative contraction of the smaller Canadian junior mining sector;
  - (b) Maintaining levels of Canadian ownership;

(c) Reversing the structural deformation and underdeveloped capabilities of the minerals machinery and equipment industry; and
(d) Ensuring that corporate strategies for enterprise development are in harmony with public policy objectives.

- *Economic challenges*
  (a) Counteracting continuing escalation of capital, labour and energy costs facing producers;
  (b) Developing innovative approaches to the financing of new mineral exploration and development; and
  (c) Improving Canada's access to international markets, especially for semifabricated mineral products.

This paper proposes some alternative government actions that will help the industry meet these challenges. However, it is exceedingly naive to suggest that the basically noninterventionist approach of the paper which does not encompass *major* new tax initiatives, government programs and legislative/regulatory changes, can bring about the reorientation and redirection of a large sector such as the mineral industry. Complementary efforts by industry and other levels of government are essential.

# The Resource Base

## Introduction

Interest in the resource base and its adequacy focuses on two levels. At the global level, the future availability of mineral resources will to some extent determine future trends in real mineral prices. At the domestic level, the adequacy of the Canadian resource base will be a dominating factor in the ability of Canadian mineral industries to remain competitive, given world price trends.

## The Global Perspective

Some estimates of the crustal abundance of major minerals, together with "reserves"[1] and additional resources, are presented in Table 1. Although it is possible to estimate the total volume of a mineral element in the earth's crust, most of the element occurs in such a thin

[1] The basic concept and terminology concerning "reserves" and "resources" that underlie this paper are explained in the accompanying sidebar, *Reserves and Resources*.

**Table 1. World production and reserves in 1977 (estimated), other resources in 1973-77 (as data available), resource potential and resource base of 17 elements**

| | Production | Reserves | Other resources | Resource potential (recoverable) | Base resource (crustal mass) |
|---|---|---|---|---|---|
| | | | (million tonnes) | | |
| Aluminum | 17 | 5 200 | 2 800 | 3 519 000 | 1 990 000 000 000 |
| Iron | 495 | 93 100 | 143 000 | 2 035 000 | 1 392 000 000 000 |
| Potassium | 22 | 9 960 | 103 000 | n.a. | 408 000 000 000 |
| Manganese | 10 | 2 200 | 1 100 | 42 000 | 31 200 000 000 |
| Phosphorus | 14 | 3 400 | 12 000 | 51 000 | 28 800 000 000 |
| Fluorine | 2 | 72 | 270 | 20 000 | 10 800 000 000 |
| Sulphur | 52 | 1 700 | 3 800 | | 9 600 000 000 |
| Chromium | 3 | 780 | 6 000 | 3 260 | 2 600 000 000 |
| Zinc | 6 | 159 | 4 000 | 3 400 | 2 250 000 000 |
| Nickel | 0.7 | 54 | 103 | 2 590 | 2 130 000 000 |
| Copper | 8 | 456 | 1 770 | 2 120 | 1 510 000 000 |
| Lead | 4 | 123 | 1 250 | 550 | 290 000 000 |
| Tin | 0.2 | 10 | 27 | 68 | 40 800 000 |
| Tungsten | 0.04 | 1.8 | 3.4 | 51 | 26 400 000 |
| Mercury | 0.008 | 0.2 | 0.4 | 3.4 | 2 100 000 |
| Silver | 0.010 | 0.2 | 0.5 | 2.8 | 1 800 000 |
| Platinum group | 0.0002 | 0.02 | 0.05 | 1.2 | 1 100 000 |

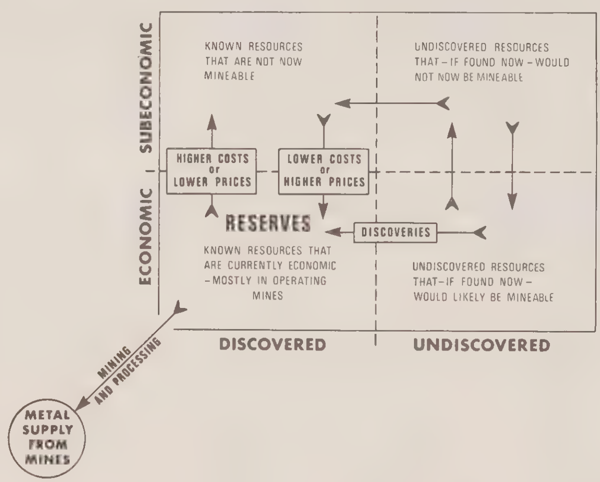
SOURCE: Council on Environmental Quality, and U.S. Department of State, *The Global 2000 Report to the President*, 1980, p. 219.
n.a.—not available.

## Reserves and Resources

Reserves and resources are two terms frequently used in discussions of minerals and the activities associated with their discovery and production. If different meanings are attached to these terms, the results can be confusing and misleading. In this paper, they are used as follows: resources are mineral concentrations—the known as well as the merely speculative—that might be drawn upon in the foreseeable future; reserves represent only the fraction of resources that have been fairly well measured and assessed as being economically mineable in the immediate future.

As the diagram shows, mineral production draws on reserves, the current working stock. At the same time, two processes are at work to replenish reserves from other resources. One is exploration, resulting in discoveries of new orebodies and extensions to known orebodies. The other process involves favourable changes in the economic outlook, which may convert some mineral resources into reserves by making them economical to mine. These include cost-lowering technological innovations and a rise in the price for a mineral commodity. In the same way, unfavourable changes in economic factors may turn reserves back into subeconomic resources.

THE FLOW OF RESOURCES OVER TIME




concentration that it probably will never become economical to exploit. For example, the average crustal concentration of copper is estimated to be about 63 parts per million, or 0.0063 per cent. However, in 1975 the lowest concentration of copper economically recoverable in an orebody without a byproduct was about 0.35 per cent — *56 times* the average crustal concentration[1].

Most estimates suggest that current levels of reserves will supply world demand until the year 2000 for all major minerals with some exceptions (see Table 2). This indicates that there is certainly no *immediate* problem of resource adequacy at the global level.

However, it is more than the physical availability of a mineral that is of interest. Rather, it is whether mineral commodities will be available at the required rates in usable form at higher, lower or approximately current real price levels over a particular time span — 10, 20 or 50

[1] R.F. Mikesell, *New Patterns of World Mineral Development* 1979, Appendix B, p. 80.

**Table 2. Life expectancies of 1974 world reserves for mineral commodities of particular concern at two different rates of demand**

| | Reserves | Demand | Projected demand growth rate | Life expectancy: Demand static at 1974 level | Life expectancy: Demand growing at projected rates |
|---|---|---|---|---|---|
| | | | (%) | (years) | |
| Industrial diamonds (million carats)* | 680 | 75 | 4.23 | 9 | 8 |
| Silver (million troy ounces)† | 6 000 | 374 | 2.33 | 16 | 14 |
| Mercury (thousand flasks)‡ | 4 930 | 236 | 0.50 | 22 | 21 |
| Zinc (million tonnes) | 236 | 5.81 | 3.05 | 29 | 21 |
| Sulphur (million tonnes) | 2 032 | 49.79 | 3.16 | 41 | 26 |
| Tungsten (thousand tonnes) | 1 780 | 38.56 | 3.26 | 45 | 28 |
| Lead (million tonnes) | 150 | 3.07 | 3.14 | 47 | 29 |
| Tin (thousand tonnes) | 10 282 | 233.69 | 2.05 | 44 | 31 |
| Copper (million tonnes) | 408 | 6.57 | 2.94 | 60 | 35 |
| Fluorine (million tonnes) | 34 | 2.08 | 4.58 | 97 | 37 |
| Platinum (million troy ounces)† | 297 | 2.70 | 3.75 | 104 | 43 |
| Nickel (million tonnes) | 54 | 0.71 | 2.94 | 90 | 44 |
| Iron ore (billion tonnes) | 91 | 0.52 | 2.95 | 216 | 68 |
| Chromium (million tonnes) | 523 | 2.45 | 3.27 | 249 | 68 |
| Manganese (million tonnes) | 1 826 | 9.27 | 3.36 | 268 | 69 |
| Potash (million tonnes) | 9 979 | 23.59 | 3.27 | 430 | 84 |
| Phosphate rock (million tonnes) | 16 068 | 111.58 | 5.17 | 1 659 | 88 |
| Aluminum in bauxite (million tonnes) | 3 484 | 15.42 | 4.29 | 1 199 | 94 |

SOURCE: Council on Environmental Quality, and U.S. Department of State, *The Global 2000 Report to the President*, 1980, p. 212.

* 1 carat = 200 milligrams.

† 1 troy ounce = 31.103 grams.

‡ 1 flask = 34.473 kilograms.

years. In the case of rising real costs, economic growth projections may not be realized in spite of efforts at substitution. This is the possibility that causes concern at the global level although, for a net exporter such as Canada, it would afford some opportunities.

Numerous forces impinging on the supply side of the mineral industries may tend to create upward pressure on real mineral prices. These include (a) rising energy costs for this energy-intensive sector, (b) rates of technological change in exploration and extraction insufficient to counteract rising costs due to declining ore grades and increasing scarcity, and (c) environmental costs.

However, in addition to the fact that there appear to be no immediate mineral supply problems on a global scale due to resource inadequacy, the demand side of minerals markets — according to most forecasts — constrains the extent to which real price increases are likely. Consumers can often use substitutes — the greater the substitutability for a given mineral, the lower the potential for real prices to rise. In addition, world economic growth is anticipated to be less than in the post-war period.

Metal recycling also will tend to reduce upward pressure on real prices. The extent to which recycling can meet future mineral demand depends largely on (a) the growth rate in mineral demand, (b) the proportion of minerals recyclable at competitive costs, and (c) the durability of the products containing the mineral. In a period of rapid growth, the impact of increased recycling on meeting the demand for minerals is limited. Recycling therefore does not pose a serious competitive threat to mineral *producing* countries in a period of rapid growth. However, it is a long-term supply factor that tends to reduce upward price pressures. This is especially true for minerals that will experience lower growth rates in demand.

Therefore, despite limits to the rates of availability of minerals and the still-popular Neo-Malthusian and "Club of Rome" pessimism, there is no clear indication that real mineral prices will rise as we move into the next century. While real prices will increase for some rarer minerals, the relative abundance of other important minerals — iron ore, bauxite and nonbauxite sources of aluminum and phosphates, for example — will hold a general minerals price index down. Thus, overall stability can be expected in the secular trend of real prices of minerals into the 1990s and perhaps the first decades of the 21st century as well. Over the shorter period of the 1980s, different minerals will exhibit various price movements as forecast in the chapter on international markets.

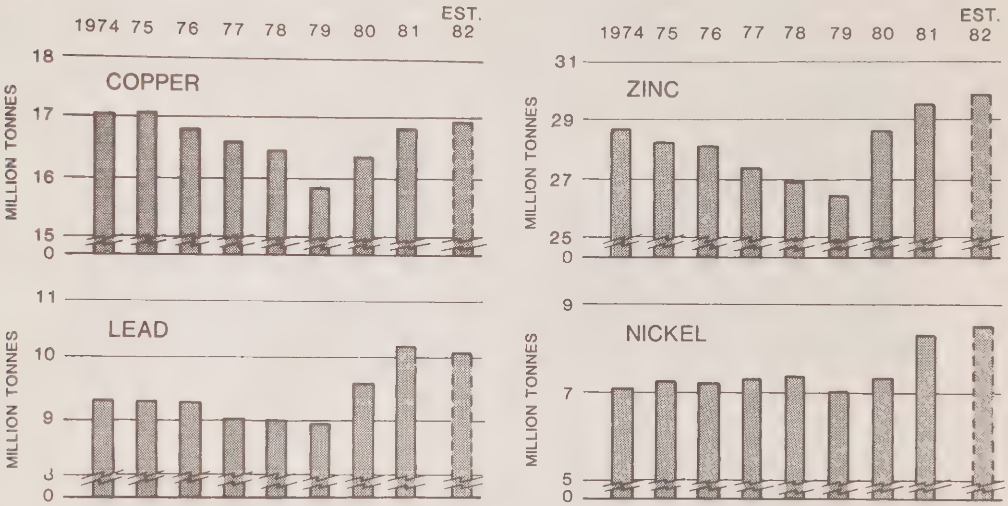
## The Domestic Perspective

Even if world resources are large and real prices remain approximately constant, there still may be considerable opportunities for a mineral-producing country like Canada. Such opportunities depend primarily on the resource endowment and the technological changes that affect it. The extent of Canada's resources has been studied in depth by the Geological Survey of Canada and the Mineral Policy Sector in EMR. The major resource categories are: (a) current reserves — resources that can be exploited economically at current prices; (b) resources that remain to be discovered but would be economical at current prices; and (c) subeconomic resources, known and unknown that might be profitable with modest increases in real metal prices or cost-reducing technological improvements.

Only the first of these can be quantified definitively. Figure 1 demonstrates the behaviour of reserve levels for four major metals mined in Canada over the recent past. All experienced growth during the 1950s and 1960s, and all but nickel declined somewhat in the 1970s. To a large extent, these variations reflect market conditions — during periods of rising prices and expectations of growing market opportunities, reserve levels are built up; during a downswing, the reverse occurs.

FIGURE 1
# LEVELS OF RESERVES

Metal contained in mineable ore, as of January 1 of each year




NOTE: Scale broken to allow annual differences to be emphasized
SOURCE: MINERAL POLICY SECTOR, EMR
CANADIAN MINES: PERSPECTIVE FROM 1981, MR 192

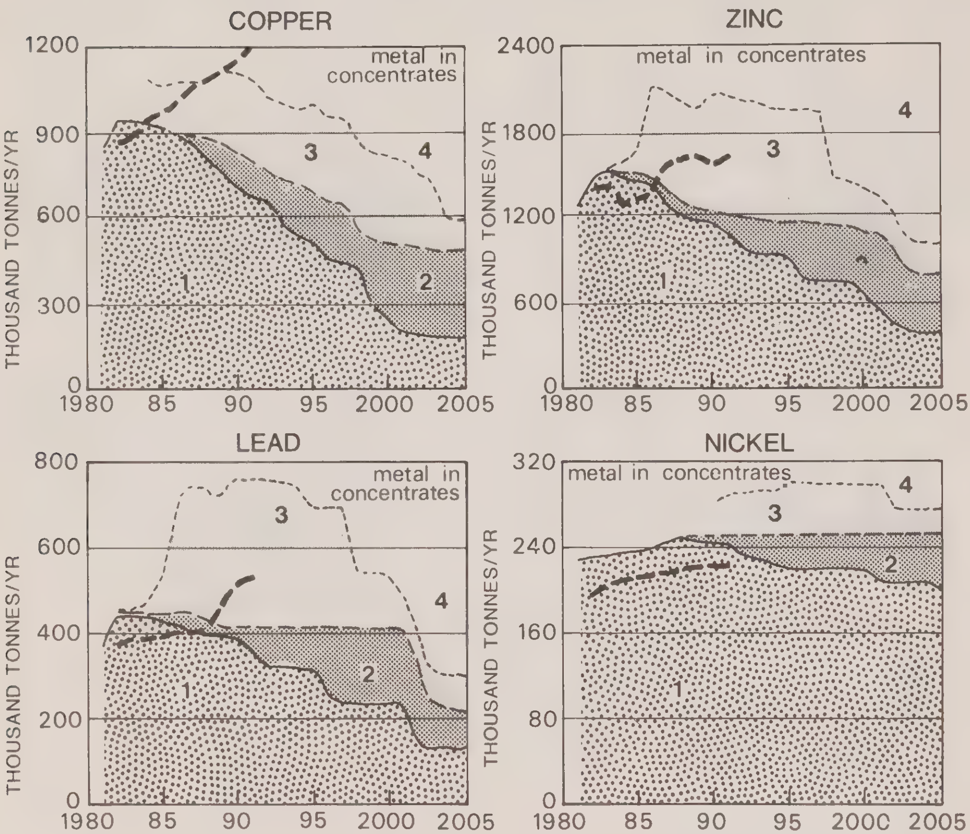
While it is not possible to accurately *predict* future trends in reserve levels, EMR has developed a *monitoring* technique that can provide early warning of adverse changes in reserve levels and production capability. Monitoring curves (see Figure 2) show how the current reserve stock will be depleted over time, assuming existing mines follow through with their planned rates of production. They indicate at what rate depletion of reserves would occur if there were to be no new additions. These curves will change from year to year with the flows that occur as mining and exploration continue.

By the year 2000 only a very small percentage of production will come from Canadian reserves on hand in 1981 (Figure 2). If reserve additions meet or exceed mining rates, the curve will maintain its position or shift outwards, whereas if reserve additions do not keep up with mining rates, the curve should shift towards the origin of the graph in Figure 2. This would be a signal that the industry may face adjustment problems — problems that can be reduced with planning. The monitoring procedure aims at early identification of such difficulties, which may relate to world markets, financial concerns, labour availability, environmental requirements or other factors.

Modern geology and exploration methods are effective in locating shallow orebodies. Most unknown deposits, at least to the depth limits of current exploration techniques — approximately 100 metres — are probably subeconomic or marginally economic at present. Therefore, unless exploration techniques with deeper penetration are applied or unless exploration extends to more remote and costly regions, the second category — undiscovered orebodies — cannot be expected to contribute to future reserve levels as much as known deposits.

FIGURE 2

# SOURCES OF FUTURE MINE SUPPLY




Production forecast

1 Capability for future production from mines operating and committed as of January 1, 1981, if no new reserves and production capacity had been or were to be added after that date ("monitoring curve")

2 Capability for additional future production from orebody extensions inferred as of January 1, 1981

3 Capability for additional future production from undeveloped deposits considered promising as of January 1, 1981

4 Uncertain supply, mostly from deposits still undiscovered or beyond foreseeable economic reach as of January 1, 1981

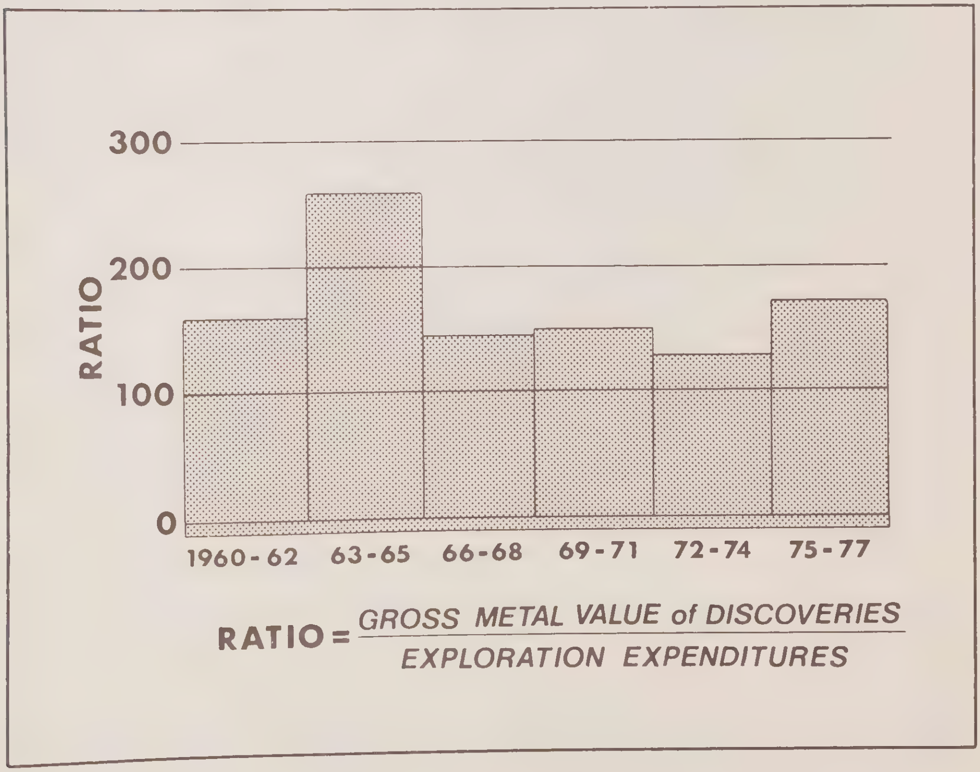
SOURCE: Mineral Policy Sector, EMR Canadian Mines: Perspective from 1981, MR 192

Many orebodies currently in production, however, have not yet been fully explored — their surmised extensions are not included in the definition of current reserves. Once sufficient economic volumes of ore are identified in an orebody to support development, it is unnecessary and unprofitable to identify further reserves until they are needed. In most major mines, new reserves are continually proven up at a rate capable of supporting 15 or 20 years' production.

The volume of minerals in the third category, subeconomic resources, is undoubtedly vast. Unfortunately, only higher real mineral prices or improvements in the technological competitiveness of the Canadian industry will maintain flows of these resources into the reserve category. Exploration often uncovers deposits of subeconomic quality by chance as firms continue to explore in the hope of finding economic orebodies. Thus, there will always be discoveries that are on the shelf while exploration continues to be an attractive investment, because of the expectation of finding economic deposits.

FIGURE 3

DISCOVERY VALUE PER EXPLORATION DOLLAR




SOURCE: Derived from Figure 4 of MRI 80-5, Canadian Ore Discoveries, 1946-78; A Continuous Record of Success, D.A. Cranstone

Past exploration trends provide an impression of the adequacy of the Canadian resource base in general. Figure 3 shows that the gross value of metal content in ore discoveries, per dollar of exploration, has remained approximately constant over the last two decades. This suggests that, on the whole, exploration incentives and the resource base have been adequate to meet the growing demands for new reserves. While this is encouraging, it still does not reveal much about the long-term future adequacy of the resource base.

It can be seen that an overwhelming problem in assessing the long-term adequacy of the Canadian resource base is uncertainty about the quality and quantities of resources that are yet undiscovered. This is because there is no economic incentive to fully explore already known mineral showings or to attempt to discover all possible orebodies. The expense of an all-encompassing search for reserves before they are required is simply not warranted on economic grounds. However, it may be advisable under certain circumstances to make greater efforts in this direction in the public interest, e.g. exploration for strategic minerals, exploration in proximity to declining communities. To summarize:

- Given the perceived magnitude of resource availability in the world as a whole, and the long-term possibility of substitution among minerals and between minerals and nonmineral commodities, a constant trend of aggregate real mineral prices can be expected. This does not preclude divergence in real price trends among individual minerals or real price increases over short periods of time.
- The Canadian resource base appears adequate to support the Canadian mineral industry into the next century at current real prices, but real price increases or technological improvements ultimately will be necessary to justify the development of a large part of the resource base.
- With certain exceptions, public policy toward the exploration and development of Canadian resources should be firmly based on economics. That is, development of the resource base should occur at the rate and to the extent warranted by the criterion of economic viability.

# Security of Supply

## Introduction

It has been argued that several recent events have heightened Western anxieties regarding the security of mineral and metal supplies. The first was the emergence during the 1970s of the Organization of Petroleum Exporting Countries' (OPEC) pervasive influence upon the global economy. Western vulnerability to oil-supply shocks created uneasiness about reliance on foreign supplies of other raw materials — especially with the developing nations exerting self-interest wherever possible.

During 1980, this concern was increased by two further events. One was the political tension in countries bordering on the Republic of South Africa, namely Zimbabwe and Namibia. In view of South Africa's prominent position as a supplier of such materials as chromium, manganese and gold, this led to renewed fears of disruptions in trade with South Africa, due either to a war there or in Namibia, or to international trade sanctions. These fears regarding South Africa have refreshed memories of recent conflicts in Zimbabwe, Uganda, Zaire and elsewhere in Africa. There is thus a wider concern for the potentially disruptive effects of localized disputes on world markets for commodities with relatively few sources of supply. Africa is usually the only region of the world discussed in this regard, but Southeast Asia is occasionally mentioned.

The second important event in 1980 was the rapid reversal of the U.S.S.R. from an exporter to an importer of some important raw materials, which has had a constricting effect over certain mineral supplies. This increased Soviet import demand is probably due to declining mineral grades and reserves, production and exploration bottlenecks, and increased military demand.

Together, it is alleged that these events have reinforced fears that the supply of important mineral commodities not only may be vulnerable to disruptive events within the exporting countries[1], but that Western dependence on such sources might be exploited for political or economic gain. However, an important mitigating factor is that most of the so-called "unstable" countries depend on a very small number of export commodities for their economic well-being. For example, Zambia depends on copper for more than 80 per cent of its export earnings. One would expect that such countries would be very anxious to maintain production and export levels under most circumstances. Nevertheless, the current degree of concern indicates that security of mineral supply warrants some attention.

## Potential Supply Problems for Canada

A great deal of study normally is needed to determine whether a supply shortage of any particular commodity would work to a country's net advantage or disadvantage. Fortunately, in

[1] The most frequently cited example is the 1978 conflict in Zaire's Shaba province. This interrupted Western cobalt supplies — Zaire provides up to 66 per cent — with the result that producer prices rose from $U.S. 13/kg (Dec. 1977) to $U.S. 55/kg (Feb. 1979) while dealer prices shot up to almost $U.S. 100/kg. Producer prices have recently fallen to $U.S. 40/kg. A principal outcome has been that substitution has reportedly affected 15 per cent of cobalt demand, particularly in magnets — with a 50 per cent substitution — which had been the leading use of cobalt. Recycling has also increased.

Canada's case, most mineral commodities do not pose a security-of-supply problem for the domestic economy. The following analysis[1] indicates that Canada might be vulnerable to economically important supply shortages for only six commodities, and of these, only two — manganese and chromium — appear to warrant active concern at this time.[2]

Table 1 shows, by percentage, the degree of Canada's reliance on imports for more than 100 minerals and related products.[3] For 76 of these, an apparent import reliance exists. Table 2 lists those minerals from Table 1 for which there is *no* apparent import reliance. Supply shortages of these minerals or their substitutes would be largely to Canada's advantage, indicating a net benefit. There were insufficient data to calculate values for ball clay, germanium, silica ferroalloys, strontium and thorium, so these materials are also excluded from the remaining tables. Similarly, cesium, hafnium, rare-earth concentrates, rhenium, rubidium and thallium are excluded because there is no available evidence of Canadian consumption of these materials, other than as contained in imports of manufactured items.

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[1] This analysis of the problem in a market economy framework raises the whole issue of comparisons with the energy sector. However, the magnitude of the oil and gas sector, and the limited scope for substitutability, implies far more painful adjustments if the price system alone is relied upon to achieve the adjustments.

[2] This confirms, for Canada, the conclusion reached by Chase Econometrics on the non-Communist world's ferroalloy supply security, and presented by them to the Metal Bulletin's Third International Ferroalloys Conference held in Athens, Greece on November 16, 1981.

[3] While long, this list is not exhaustive as it does not include mineral fuels, some elements and a few minor minerals.

**Table 1. Apparent Canadian import reliance* for minerals and related commodities (1979)**

| | (%) |
|---|---|
| Lightweight aggregates: pumice, perlite, vermiculite | 100 |
| other (1978) | 0 |
| Aluminum: bauxite | 100 |
| alumina (1978) | 45 |
| primary aluminum (1978) | 0† |
| Antimony: ores and concentrates | 0 |
| lead alloy | 92‡ |
| oxide; metal | 100 |
| Asbestos: crude; manufactured | 0 |
| Barite: crude, ground and chemical | 0 |
| Bentonite | 75 |
| Beryllium: metal; alloys | 100 |
| Bismuth: ores and concentrates; metal | 0 |
| Boron: boric oxide, sodium borate, ferroboron | 100 |
| Bromine: ethylene bromide | 100 |
| Cadmium (1978): ores and concentrate; metal | 0 |
| Calcium: metal | 0 |
| Cement: portland and other; products; refractory | 0 |
| Cesium: pollucite | px |
| metal and compounds | np,ndc |
| Chromium: ores and concentrates; ferrochromium, other | 100 |
| Clays: common clays and shale | 0 |
| fireclay (1978) | 26(am) |
| ballclay | na |
| kaolin (china clay) | 100 |
| fuller's earth | 29 |
| Cobalt (1978) ores and concentrates; metal; oxides | 0 |
| Columbium: pyrochlore (1978) | px |
| ferrocolumbium | 100‡ |
| Copper (1978): ores, concentrates and scrap; refinery shapes; products | 0 |
| Diatomite | 95 |
| Feldspar | 100 |
| Fluorspar and natural cryolite (1978) | 100 |
| Gallium: metal | 0 |
| Germanium: in zinc concentrate | px |
| metal | na |
| Gold: all forms in aggregate | 0 |
| Gypsum and anhydrite | 0 |
| Hafnium | ndc,p |
| Indium | 0 |
| Industrial diamonds: stone and dust | 100 |
| Iodine | 100 |
| Iron ore (1978) | 0 |
| Iron and steel | 0 |
| Kyanite | 100 |
| Lead (1978): ore, concentrates and scrap; fabricated | 0 |
| Lime | 0 |
| Lithium compounds | 100 |
| Magnesium metal and alloys | 0 |
| (1978): magnesite | 69 |
| Manganese: ores and concentrates; | |
| metal | 100 |
| ferromanganese (1977) | 6 |
| silicomanganese and spiegeleisen (1977) | 47.5(am) |

**Table 1 (concluded).**

| | (%) | | (%) |
|---|---|---|---|
| Mercury | 100 | Silver: ores and concentrates; metal | 0 |
| Mica: block, sheet and ground | 70 | Sodium: sulphate | 0 |
| Molybdenum ores, concentrate and scrap; | | metal | 100 |
| oxides; ferromolybdenum (1978): | 10-12 | Stone crushed | 0.67 |
| Natural abrasives | 100 | (1978): rough | 3 |
| Natural graphite | 100 | shaped or dressed | 59(am) |
| Nepheline syenite | 0 | crude nes and basic products | 0 |
| Nickel: all forms in aggregate | 0 | Strontium carbonate: celestite; compounds | na |
| Phosphate rock and ferrophosphorus | 100 | Sulphur (1978): crude and refined; acid and | |
| Platinum group (1978): ores, concentrates | | oleum | 0 |
| and scrap | 0 | Talc (1978) | 58.5 |
| refined | 100 | Tantalum: pentoxide (1978) | 0 |
| Potash: fertilizer potash | 0 | metal and alloys | 100 |
| Pyrophyllite (1978) | 0 | Tellurium | 0 |
| Rare earths: concentrate | nc,p | Thallium | ndc,p |
| compounds and ferro- | 100 | Thorium | na |
| Refractories (firebrick and similar shapes) | | Tin: ores, concentrates and scrap (1978) | 0 |
| (1978): total | 52.5 | tinplate (1978) | 36.5 |
| magnesite only | 77 | metal | 95 |
| silica only | 84.5 | Titanium: slag and dioxide (from | |
| Rhenium: ores and concentrates | px | ilmenite) (1978) | 0 |
| perrhenic acid | np,ndc | metal (from rutile) | 100 |
| metal | ndc,p | ferrotitanium (1978) | 90-100 |
| Rubidium | ndc,p | Tungsten: ores and concentrates | 0 |
| Salt | 0 | ferrotungsten | 100 |
| Sand and gravel | 0.33 | metallic carbides (1978) | 42(am) |
| Selenium | 0 | Vanadium: ores and concentrates; | |
| Silica metal; ferrosilicon | 0 | pentoxide; alloys | 100 |
| (1978): sand, quartz and silex | 46 | ferrovanadium (1978) | 0 |
| ferroalloys | na | Zinc: all forms in aggregate | 0 |
| crude artificial abrasives | 0 | Zirconium: all forms | 100 |
| refined artificial abrasives | 100 | | |

SOURCES: Canadian Minerals Yearbook: 1979 (preprints), 1978, 1977; Statistics Canada #41-010, 013, 203; #65-202, 203, 207; U.S. Mineral Yearbook: 1978-79, 1977; U.S. Trade Statistics: 1978, 1977; U.S. Bureau of Mines: Commodity Profiles, Minerals in the U.S. Economy, Mineral Commodity Summaries; Roskill Information Services; Energy, Mines and Resources MR1 80/20, 81/7; Energy, Mines and Resources MR 188.

*Apparent import reliance = (imports – exports) ÷ consumption.

†An assessment of zero import reliance for primary aluminum is, of course, contingent upon 100% availability of bauxite/alumina.

‡Canadian production capacity significantly underutilized.

am—at most.
nc,p—no domestic consumption, production.
ndc, p—no definite domestic consumption, production.
na—not calculable with available information.
px—produced entirely for export (i.e., nc).
nes—not elsewhere specified.

Table 3 shows domestic materials in Table 1 for which Canada's import reliance is entirely due to Canadian ores being processed abroad — in Japan, the United States and Western Europe. Their supply thus is not in any likely jeopardy and, in fact, represents a bargaining lever for the government should circumstances ever dictate that market intervention is necessary. Table 4 reduces the original list of 76 still further by denoting those materials for which an apparent import reliance simply reflects an overall imbalance in regional trade with the United States. These are mainly high-volume, low unit-value commodities. Table 5 lists those

**Table 2. Materials for which Canada has no apparent import reliance**

| | | |
|---|---|---|
| Lightweight aggregates: clays, shale and slag | | Potash |
| Asbestos | Gold | Pyrophyllite |
| Barite | Gypsum and anhydrite | Salt |
| Bismuth | Indium | Selenium |
| Cadmium | Iron ore | Silicon: metal |
| Calcium | Iron and steel | Silver |
| Cement | Lead | Sodium sulphate |
| Clays: common | Lime | Sulphur |
| Cobalt | Magnesium | Tellurium |
| Copper | Nepheline syenite | Titanium dioxide (ilmenite) |
| Gallium | Nickel | Zinc |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

**Table 3. Import reliance entirely due to the processing of domestic minerals abroad (content of exported ore and concentrates greater than content of imported material)**

| | | |
|---|---|---|
| Antimony | Platinum group | Tantalum |
| Columbium | Silica: artificial abrasives | Tungsten |
| Molybdenum | | |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

**Table 4. Import reliance due to imbalance in regional trade* with United States**

| | | |
|---|---|---|
| Refractories | Sand and gravel | Stone, crushed |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

*Trade that is mainly between U.S. and Canadian communities near the border.

**Table 5. Percentage of imports originating in the United States (1979)***

| | (%) | | (%) | | (%) |
|---|---|---|---|---|---|
| Lightweight aggregates: Perlite | 99 | Clays: fireclay | 100 | Mica | 99 |
| Pumice | 80 | kaolin | 87 | Natural abrasives | 96 |
| Vermiculite | 82 | fuller's earth | 100 | Phosphate rock | 99 |
| Bentonite | 75 | | | ferrophosphorus | 100† |
| Beryllium | 100 | Diatomite | 100 | Rare earths: ferro | 96 |
| Boron, boric acid | 71 | Feldspar | 84 | compounds | 80‡ |
| boric oxide | 100 | Kyanite | 100‡ | Silica: sand, silex | 99 |
| borax | 73 | Magnesite | 70 | Talc | 99 |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

*Import reliance mainly represents trade with United States where United States is not itself import reliant and has adequate reserves.

†1978.

‡Estimated.

materials for which we rely upon the United States and for which the U.S. Bureau of Mines has evaluated their reserves as adequate. This rule for elimination, of course, assumes that the United States is a safe source of supply.

So far, the process of elimination has reduced the original list of 76 to 14 candidates for detailed consideration. Of these, four can be ignored because there are widespread and mainly non-Communist sources of supply and large global reserves (Table 6). These characteristics make cartelization unlikely and indicate that the market would have little difficulty in coping with supply disruptions due to regional conflicts. Another four can be eliminated since they are very minor imports or are not particularly vital to the economy (Table 7).

For the final six[1] candidates, Table 8 presents the value of Canadian net imports (1978), the top three sources and their share of Canadian imports, U.S. import reliance for the raw

[1] Rutile and titanium metal can be considered a single candidate since any study of the titanium metal situation would require reference to its main raw material, which is rutile.

**Table 6. Widespread supply (mainly non-Communist) and large global reserves**

| | Top 5 producers | Other producers | |
|---|---|---|---|
| | | Number | Share |
| | (% of world production) | | (%) |
| Bauxite | Australia (29.7), Guinea (14.6), Jamaica (14.4), Surinam (6.4), U.S.S.R. (5.6) | about 18 | 29.3 |
| Fluorspar | Mexico (15.3), France (12.2), U.S.S.R. (11.1), South Africa (8.5), Spain (8.3) | 21 | 44.6 |
| Natural graphite | South Korea (11.3), Mexico (10.6), Austria (8.2), Malagasy Republic (3.5), West Germany (2.6) | 14 | 63.8 |
| Tin | Malaysia (25.6), U.S.S.R. (13.5), Bolivia (12.6), Thailand (12.4), Indonesia (9.8) | min. 10 | 26.1 |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

**Table 7. Imports that are from a small group of producers but are negligible in amount and/or necessity**

| | 1979 value of imports | Top 3 sources of Canadian imports | Main producers |
|---|---|---|---|
| | ($) | (% of Canadian imports) | (% of world production) |
| Iodine | 1.8 million | Japan (92.4), U.S. (7.6) | Japan (51.8), U.S.S.R. (18.8), Chile (18.0), U.S. (7.5)* |
| Mercury | 502 000 | Spain (52.0), U.S. (37.8), Puerto Rico (8.2) | U.S.S.R. (34.1), Spain (17.6), Algeria (17), U.S. (13.7) |
| Natural cryolite | 206 000 | Denmark (81.1), U.S. (16.0), Dominican Republic (2.9) | Denmark (100) |
| Stone, rough | 5.0 million | U.S. (39.1), South Africa (32.9), Italy (25.8) | n.a. |
| shaped or dressed | 3.2 million | Italy (61.8), U.S. (14.7), South Africa (10.4) | n.a. |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

*Estimate.

n.a.—not available.

**Table 8. The remaining six candidates**

**(a) Canadian Imports (1978)**

| | | Canadian net imports | Top 3 import sources 1978 | U.S. import reliance for ore |
|---|---|---|---|---|
| | | ($) | (% of Canadian imports) | (%) |
| Chromium: | ores | 6 million | Philippines (43.2), U.S. (24.8), Finland (12.3) | 90 |
| | ferro | 16.6 million | U.S. (47.2), South Africa (37.4), Brazil (9.7) | |
| | other | 4.5 million | U.S. (71.2), U.K. (20.6), West Germany (4.9) | |
| Industrial diamonds: | | 8.8 million | U.S. (58.6), Ireland (27.2), Belux (8.1) | 100 |
| Dust | | 2.5 million | U.S. (99.2), Ireland (0.5), U.K. (0.2) | |
| Manganese: | ore | 18.4 million | Brazil (34.8), U.S. (24.7), Gabon (20.2) | 98 |
| | metal | 7.1 million | South Africa (93.1), U.S. (3.5), Japan (3.2) | |
| | ferro- | 8.1 million | South Africa (38.6), Norway (32.8), U.S. (23.3) | |
| | silico- | 7.2 million | U.S. (40.4), Norway (33.6), South Africa (10) | |
| Titanium: | metal | 3.6 million | U.S. (80.6), U.K. (11.3), Belux (3.9) | (ore is rutile: 100) |
| | ferro | n.a. | U.K. (90[e]) | metal: 10–15[e] |
| Vanadium: | ore | 760 000 (min) | U.S. (n.a.) at least | 25 |
| | pentoxide | 1 019 000 (min) | U.S. (72[e]) | |
| | ferro- | 0 | U.S. (71.4), South Africa (28.6) | |
| | alloys | 1 100 000 (min) | U.S. (83[e]) | |
| Zirconium: | ore | 1 324 000 (min) | Australia (82.6[e]) | approx. 75[e] |
| | ferro- | n.a. | n.a. | |
| | alloys | 8.8 million | U.S. (96.7), France (3.3) | |
| | oxide | 845 000 (min) | U.S., at least | |

**(b) World production (1978)**

| | Top 5 ore producers | Other producers | |
|---|---|---|---|
| | | Number | Share |
| | (% of world production) | | (%) |
| Chromium ore | South Africa (32.8), U.S.S.R. (24.2), Albania (10.4), Turkey (7.4), Zimbabwe (6.3) | 13 | 18.9 |
| Industrial diamonds | Zaire (32.5), U.S.S.R. (28.7), South Africa (18.9), Botswana (8.4), Ghana (6.3) | 12 | 5.2 |
| Manganese ore | U.S.S.R. (39.3), South Africa (20.5), Gabon (8.1), India (7.4), Australia (6.1) | 21 | 18.6 |
| Rutile | Australia (79.8), U.S.S.R. (9[e]), South Africa (5.4), India (2.2), Brazil (0.1) | 2 (min) | 3.5 |
| Titanium metal | U.S.S.R. (54.3[e]), U.S. (26.4[e]), Japan (14.5), U.K. (3.4), China (1.4) | — | — |
| Vanadium ore | South Africa (38.3), U.S.S.R. (30.8), U.S. (16.1), Finland (10.3), Chile (2.3) | approx. 2 | 2.2 |
| Zirconium | Australia (69.2), U.S.S.R. (13), U.S. (9.8[e]), South Africa (3.3), India (2) | approx. 7 | 2.7 |

**Table 8 (concluded).**

**(c) 1978 Reserves/Production (approximate in most cases)**

| | Top 5 producers | Rest of world |
|---|---|---|
| Chromium ore (millions tonnes, gross weight) | South Africa (2268/3.2), U.S.S.R. (23^e/2.3), Albania (n.a./1.0), Turkey (5.0/0.68), Zimbabwe (998/0.6) | 51.1 min/1.7 |
| Industrial diamonds (million carats) | Zaire (500/9.3), U.S.S.R. (25/8.2), South Africa (50/5.4), Botswana (50/2.4), Ghana (25/1.8) | 30/1.5 |
| Manganese (million tonnes, gross) | U.S.S.R. (2359/8.6), South Africa (1996/4.31), Gabon (150/1.7), India (59/1.5), Australia (299/1.3) | 581/3.5 |
| Rutile (thousand tonnes, gross) | Australia (9072/266), U.S.S.R. (2722 max/30 max), South Africa (1814/18), India (7258/7), Brazil (90 719/1.4) | 9072/12 |
| Titanium metal: (capacity/production) (thousand tonnes, sponge) | U.S.S.R. (38/34), U.S. (21.3/16.8^e), Japan (14.0/9.2), U.K. (2.7/2.2), China (1.8/0.9) | — |
| Vanadium (thousand tonnes, contained V) | South Africa (7802/11.2), U.S.S.R. (7258/9), U.S. (104/4.7), Finland (227/2.9), Chile (136/0.7) | 272/0.7 |
| Zirconium (thousand tonnes, gross) | Australia (14 515/397), U.S.S.R. (2722*/36*min), U.S. (7258/70^e), South Africa (3629/36), India (907*/5.4^e*) | 3357*/7.5 |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

* Thousand tonnes, contained Zr (1975-77 values).
min—minimum.
max—maximum.
^e—estimated.
n.a.—not available.

material, the top five producers and their share of world production, the number of other producers and their aggregate share of total production, and the 1978 levels of reserves and production for the top five producers and for the other producers in aggregate. These latter figures — reserve volumes and production levels — are, in most cases and especially for the U.S.S.R., quite approximate. However, they indicate the magnitudes involved with reasonable reliability. Table 9 gives their uses, end uses and substitutes, mainly in the United States. Table 10 lists Canadian resources, noted mainly in the *Canadian Minerals Yearbook*.

Table 11 shows the final verdict on which of the six should receive detailed considerations for security-of-supply purposes. Rutile (for titanium metal) and zirconium are dropped largely because Australia can be considered a safe source of supply and because substitutes exist for their major uses. Also, zirconium and ilmenite (for making synthetic rutile) are available in Canada should development of a domestic source of supply be considered necessary.

Titanium metal is removed from the list for several reasons. One is that Canada's imports are mainly from the United States, which is itself only about 15 per cent import-reliant. Although the U.S.S.R. is a major producer, most of this output is consumed domestically. Soviet exports are readily marketable in the West, but do not account for an alarming share of

**Table 9. Uses and substitutes***

| | Uses | (%) | End uses | (%) | Substitutes |
|---|---|---|---|---|---|
| Chromium | Metallurgical<br>Chemical<br>Refractory | 61<br>21<br>18 | Construction<br>Machinery and equipment<br>Transportation<br>Refractories<br>Other | 20<br>15<br>15<br>10<br>38 | Nickel, zinc, cadmium, good for corrosion protection of iron and steel; aluminum and plastics for trim; nickel, cobalt, molybdenum or vanadium for alloying; titanium and cadmium in chemical uses; magnesite and zircon in refractories |
| Industrial diamonds | Machinery<br>Transportation<br>Shaping of ceramic products<br>Contract construction<br>Other | 33<br>20<br>17<br>11<br>19 | | | Manufactured and natural abrasives, synthetic diamonds are acceptable for almost all uses except for hard rock and cement core drilling |
| Manganese | Mainly ferro, also into pig iron, dry cell batteries and chemical processes | | Transportation<br>Construction<br>Machinery<br>Other | 23<br>20<br>15<br>42 | No satisfactory substitute in major application (desulphurizing, deoxidizing and conditioning steel) |
| Rutile | Titanium dioxide pigment<br>Welding rod coating<br>Other, including titanium metal | 80<br>3<br>17 | | | Ilmenite, titaniferous slag and synthetic rutile are almost perfect substitutes |
| Titanium metal | Aerospace<br>also chemical and electrochemical processing, steel and alloys | 65 | | | High strength, low alloy steels, aluminum, nickel steels and other metals but may be some loss in performance |
| Vanadium | Mainly alloying for iron and steel; also in producing titanium alloys; catalyst in producing sulphuric acid | | Transportation<br>Machinery<br>Construction<br>Chemicals<br>Other | 34<br>30<br>19<br>5<br>12 | Columbium, molybdenum, manganese, titanium, tungsten. Platinums in chemical processes Depends almost entirely on cost |
| Zirconium | Foundry sands<br>Refractories<br>Ceramics<br>Abrasives<br>Miscellaneous (including chemicals and nuclear uses) | 42<br>30<br>12<br>4<br>12 | | | Chromite and silicates in foundries |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.
*U.S. data.

the market. As Soviet exports have begun to decline and demand has been increasing, new additions to Western production capacity are being planned. The relatively small number of producing countries is largely a result of the volatility, over the last 25 years, of demand for this metal.

Vanadium is dropped since Canada imports mainly from the United States — 75 to 100 per cent — which is itself only 25 per cent import-reliant. Furthermore, it has been estimated

**Table 10. Undeveloped Canadian resources**

| | |
|---|---|
| Chromium | Large resources in Bird River area of Manitoba and the Eastern Townships of Québec. Former is low grade and has a high iron content. Latter was mined during World War II |
| Industrial diamonds | None are known but could theoretically exist |
| Manganese | Several low-grade deposits in Nova Scotia, New Brunswick and British Columbia. New Brunswick has 45 million tonnes (11% manganese, 14% iron). No technological problems, but processes not proven at commercial scale |
| Rutile | None are apparently known. However, Canada produces and processes a great deal of ilmenite for pigments |
| Vanadium | Widespread in Canada, as it is in the rest of the world, especially in titaniferous magnetites. Also associated with uranium ores. Great Canadian Oil Sands (Suncor) could produce 800 tonnes/year. Latter source requires technological refinement, former does not |
| Zirconium | Plentiful in Alberta tar sands, mineral sands in Nova Scotia, some igneous rocks of Ontario and Québec. Great Canadian Oil Sands and Syncrude could together produce 37 000 tonnes/year. Technology being refined |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

**Table 11. Determination of need for further study for security of supply**

| | | |
|---|---|---|
| Chromium | Yes | |
| Industrial diamonds | No | Substitutes exist for nearly all uses. Substitutes being developed for principal exception: hard rock drilling |
| Manganese | Yes | |
| Rutile (for titanium metal) | No | Metal demand accounts for only 15% of rutile production and synthetic rutile can be made from ilmenite, which is far more abundant. Australia can be considered a safe producer |
| Titanium metal | No | U.S.S.R. only questionable Western source of supply (China is a very minor producer). Most Soviet production for domestic use. Reduction in Soviet exports would not create serious shortfall in West. Several additions to Western production capacity being planned. Also, imports are mainly (80%) from the United States, which is itself only about 15% import reliant |
| Vanadium | No | Imports are mainly (75–100%) from the United States, which is itself only 25% import reliant. Further, it has been estimated that only a 7% shortfall in Western consumption would occur if South Africa stopped exporting. Also occurs in abundance |
| Zirconium | No | Australia can be considered a safe producer. Substitutes exist for all major uses |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

that only a 7 per cent shortfall in Western consumption would occur if South Africa stopped exporting. Also, it occurs in abundance around the world, including Canada, and a great deal of coproduct supply would become available if the price were to rise. Finally, there are a wide number of acceptable substitutes for vanadium.[1]

Industrial diamonds are removed from the list since synthetic diamonds are acceptable substitutes in most uses. The main exception is for core drilling in hard-rock formations or concrete; however, technical improvements are making substitution more feasible in this market segment. In any event, this use, being the least substitutable, would outbid other uses for the

[1] For a description of the Canadian vanadium market and global vanadium supply capability, see *Vanadium*, EMR, MR 188, 1981.

available diamond supply. This supply would likely remain at an acceptable level, given the stocks held by consumers, DeBeers and the large number of small producers.

The final short list of candidates is composed of manganese and chromium, in that order of importance.

## Recommended Response to Supply Problems

Detailed studies are needed to determine Canada's vulnerability to shortages of manganese and chromium, the potential impact of such shortages, and the most cost-effective response. Although no definite conclusions can be made regarding appropriate responses until these studies are available, the following elements would be prominent considerations.

For longer run concerns, domestic sourcing and research and development are indicated. Canada has deposits of both manganese and chromium. Indeed, the chromium deposits in the Eastern Townships of Québec were mined during The Second World War. The preferred option may be to update reserves of these minerals and prepare contingency production plans.

Recovery processes for low-grade manganese deposits — which is the type Canada has — have been developed, but only at the laboratory scale; these would need to be proven at a commercial scale. In another area of R&D, some substitutes could be evaluated. This is especially applicable to chromium where substitutes already exist for many of its uses. Also, new technology being developed in the U.S. private sector may permit substitution of microcrystalline alloys made directly from molten iron alloys, or of steel coated with metallic glass or microcrystalline alloys, for stainless steels made with chromium. There is less opportunity for such technical development with manganese, as no satisfactory substitutes exist in its major application as a desulphurizing, deoxidizing and conditioning agent in steelmaking.

To meet both short- and long-run supply difficulties, contingency procurement and allocation plans can be drawn up. Since supplies of manganese and chromium are unlikely to dry up completely, such planning might be sufficient to guide the economy through the period of most severe shortages before new supplies appear on the market. The private sector may well take the preliminary steps toward such arrangements as a matter of course, since these would represent low-cost precautionary measures.

With respect to short-run difficulties, spot shortages are always a possibility — a risk that the industry takes in its stride. One common measure of protection is to maintain inventories of supplies. Table 12 indicates that private stockholdings of manganese ore represent about a six month supply, with about a one month supply of ferromanganese. These, plus material in the international system, as well as the possibility of diversifying supply sources to the numerous minor producers, indicate that a total interruption of imports from current supplies would have to endure for nearly a year before creating severe economic difficulties.

Domestic private stocks of chrome ore amount to about a two month supply, and of ferrochrome about one month. This is certainly a less comfortable cushion than that for manganese, but the difference may reflect industry's evaluation of the relative importance and supply vulnerability of the two materials. It quickly becomes quite expensive to cover the possibility of shortages persisting beyond available stocks. For example, the current cost of purchasing the equivalent of one year's imports would be $41 million for manganese and $27 million for chromium. The total cost of stockpiling would, of course, be somewhat greater.

Again, the above discussion represents only a preliminary assessment. The preferred response would depend on the exact nature of the anticipated emergency and the net social cost of exercising each available option. For now, current public- and private-sector activities

**Table 12. Consumption of chrome ore, manganese ore, ferrochrome and ferromanganese (1977)**

| | | Gross weight |
|---|---|---|
| | | (tonnes) |
| Used during the year | Chrome ore | 30 299 |
| | Ferrochrome: high carbon | 21 340 |
| | low carbon | 7 095 |
| | Manganese ore | 182 157 |
| | Ferromanganese: high carbon | 64 902 |
| | medium carbon | 6 899 |
| | low carbon | 499 |
| On hand December 31 | Chrome ore | 5 785 |
| | Ferrochrome: high carbon | 2 062 |
| | low carbon | 418 |
| | Manganese ore | 87 737 |
| | Ferromanganese: high carbon | 5 100 |
| | medium carbon | 787 |
| | low carbon | 119 |

SOURCES: Statistics Canada #41-010.

**Table 13. Minerals not currently produced in Canada that probably could be if prices rose significantly (especially those with an x)**

| | | | |
|---|---|---|---|
| Lightweight aggregates: | Perlite | Clays: kaolin | Natural abrasives |
| | Pumice (x) | Feldspar (x) | Phosphate rock |
| | Vermiculite | Fluorspar (x) | Strontium carbonate (x) |
| Bentonite (x) | | Manganese | Vanadium |
| Beryllium | | Mercury (x) | Zirconium |
| Chromium | | | |

SOURCES: Resource Strategy and Economic Analysis Branch, EMR, based on numerous sources.

directed towards the development of new processing techniques and acceptable substitutes for these two materials and their related commodities should continue to be encouraged.

## Other Implications of Supply Problems

What are the implications for Canada of (a) the indirect income losses if our trading partners are faced with a mineral supply problem that reduces their economic activity, and (b) the actions taken by Japan, the United States and EEC in response to their vulnerability to supply shortages? Regarding the first issue, it is apparent that even if Canada were completely self-sufficient in all minerals, the Canadian economy still would be negatively affected if the major industrialized countries were cut off from supplies of metals essential to maintaining their industries. As the output of foreign economies would drop, Canada's exports would decline, with obvious implications for Canadian industrial activity.

On the other hand, U.S., Japanese and EEC policies designed to cope with supply shortages might represent opportunities for the development of Canadian sources. Table 13 shows a list of minerals, currently not being produced, for which this may be true. This domestic capability could be utilized in other ways that are less reliant upon the market. For example,

Canada could seek access to foreign technological capabilities as part of an agreement to develop marginal deposits as a source of supply for the sponsoring country. Bilateral agreements could be negotiated whereby financing on convenient terms would be provided by a country in return for dedication of part or all of the production of a particular deposit. Or, such production capability could be used as leverage in negotiating swap agreements.

Foreign actions to hedge against supply shortages could also operate against Canadian interests. For instance, a popular response has been to pursue aid and assistance agreements between developed and developing countries. Where there is subsidization of mineral developments in the Third World, there will be some erosion of Canada's competitive position. This applies to financing and technology assistance. Stockpiling is usually pursued so as not to interfere with the market, but it could have some impact — large purchases could help to firm up soft markets while ill-timed releases could actually cause prices to further deteriorate. In fact, the threat of releasing excess stocks could conceivably be used as a negotiating tactic by the stockholders. At any rate, systematic stockpiling is unlikely to affect the cycle very much but could remove the rent opportunities available to producers during shortages.

In general, most developed countries seem to be pursuing the tied-assistance or buy-back option[1], which operates to Canada's disadvantage. Still, there may be some opportunity to exploit other economies' dependence on our mineral resources by obtaining general trade concessions, swap agreements or subsidized financing in return for guaranteed maintenance of normal trade volumes during a time of shortages.

Detailed analysis of the manganese and chromium supply-and-demand situation is required before selecting an appropriate policy response to deal with a possible security-of-supply problem for Canada. This can be accomplished under the current EMR program of market studies of selected imported minerals. A three-phase course of action is advisable at this time: (a) evaluate the economic losses from any interruption of supply, (b) increase the effort to delineate known deposits and to discover new deposits of these minerals, and (c) improve knowledge of extraction technology for low-grade ores of these minerals.

An evaluation should also be undertaken of various mutually beneficial mineral supply-related accords that might be proposed to Japan, the United States or the EEC. If any are found to be feasible, representation could then be made to the countries involved.

A greater effort must be made to improve basic intelligence on minerals *consumed but not produced* in Canada. In addition, the strategic minerals policies of foreign governments need to be closely monitored.

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[1] This is an agreement to purchase the output from a mineral development partly or wholly financed by the buyer. The Japanese have used this technique in various forms.

# Competitive Position

## Introduction

The competitive position of the Canadian mineral industry on international markets will, to a large measure, determine its performance in the years to come and its contribution to the Canadian economy. The following assessment of Canada's competitive position is based on relative costs. The focus is on the cost relationship of the Canadian mineral industry relative to other mineral exporting nations — the lower the cost associated with a mineral deposit in Canada, the more price-competitive it is relative to other deposits in the world.

The main factors affecting the cost of mining and processing minerals can be divided into two categories: those related to the ore deposit itself, and external factors. The former includes deposit size, ore grade, type of ore — including coproducts and byproducts — depth of deposit and remoteness from existing infrastructure. The external factors include labour, energy, material and other operating costs, capital costs, environmental protection costs, productivity and technology, the level of taxation, mineral prices, and the exchange rate. In addition, there are numerous other factors that can indirectly affect competitive position — foreign tariffs, nontariff trade barriers, international agreements, etc. These can be considered as a third category, external factors not related to cost. Assessment of competitive position requires that all three categories be considered and their relative importance weighed.

In a policy context, it is important to assess the extent to which any factor is amenable to alteration through government intervention. Clearly, the factors in the first category lie beyond government control, although the discovery and development rate of ore deposits can be influenced indirectly by government through policies affecting the economic climate within which exploration and development are conducted, and through the provision of geoscientific information and mineral R&D. The same, however, is not true for factors in the second and third categories which, in most cases, are the same as those affecting other industries. These factors can be directly influenced by government policies, though clearly within limits. Government can, for example, directly affect the competitive position of the Canadian mineral industry by changing the level of taxes imposed on mining, the level of environmental protection, energy prices and the exchange rate.

## Ore Grade, Type of Ore Deposit and Location

The most important factors affecting competitive position are ore grade and type. Copper can serve as an example to illustrate the importance and trend in ore grades and types — copper is probably as close as one can get to a "representative" mineral for Canada.

Table 1 shows that average ore grades for all known Canadian reserves of copper fell significantly from 1960 to 1976, compared to ore grades in other countries. This is not an altogether unwelcome development, since it implies that technological advances in the 1960s and 1970s greatly reduced the economic cut-off grade for large-scale, open-pit porphyry copper deposits which, in turn, had the effect of significantly expanding Canada's copper reserves. The fact remains, however, that ore grades in Canada are considerably lower than the world average. This is reinforced by Table 2, which shows that the average ore grade for producing mines

**Table 1. Evolution of copper ore grades in Canada, other major producing countries and the world**

| | 1960 | 1968 | 1976 |
|---|---|---|---|
| | | (%) | |
| Canada | 1.70 | 0.90 | 0.62 |
| United States | 0.80 | 0.77 | 0.71 |
| Chile | 1.97 | 1.29 | 1.07 |
| Peru | 0.91 | 0.98 | 0.93 |
| Zaire | 4.00 | 4.00 | 4.05 |
| Zambia | 3.71 | 3.40 | 3.02 |
| Philippines | – | 0.54 | 0.50 |
| Mexico | – | 0.60 | 0.67 |
| Papua New Guinea | – | 0.47 | 0.61 |
| World | 2.03 | 1.20 | 0.96 |

SOURCES: U.S. Bureau of Mines, *Commodity Data Summary;* and Gluschke, W., Shaw, J., Varon, B., *Copper: The Next Fifteen Years,* A United Nations Study.

**Table 2. World copper reserves, by category and average grade (1976)**

| | Reserves at producing mines (copper content) | Average ore grade | Total known reserves (copper content) | Average ore grade | Difference between total and producing mines |
|---|---|---|---|---|---|
| | (million tonnes) | (%) | (million tonnes) | (%) | |
| Canada | 16.5 | 0.70 | 24.4 | 0.62 | – 11.4 |
| United States | 60.4 | 0.71 | 80.1 | 0.71 | – 0.0 |
| Mexico | 11.7 | 0.60 | 23.4 | 0.67 | +11.7 |
| Peru | 9.4 | 1.07 | 27.3 | 0.93 | – 13.1 |
| Chile | 58.5 | 1.11 | 79.8 | 1.07 | – 3.6 |
| Zaire | 30.9 | 3.90 | 41.6 | 4.05 | + 3.8 |
| Zambia | 26.5 | 3.06 | 27.3 | 3.02 | – 1.3 |
| Philippines | 9.4 | 0.54 | 15.9 | 0.50 | – 7.4 |
| Papua New Guinea | 4.1 | 0.47 | 6.5 | 0.61 | +29.8 |
| Australia | 5.4 | 2.58 | 6.2 | 2.59 | + 0.4 |
| World | 292.0 | 1.03 | 451.2 | 0.96 | – 6.8 |

SOURCE: Gluschke, W., Shaw, J., Varon, B., *Copper: The Next Fifteen Years,* A United Nations Study, p. 51.

in Canada is 0.7 per cent, among the lowest in the world and significantly below the world average of 1.03 per cent. In other words, the grade of copper ore currently being mined in Canada is, on average, below that of all major competitors except the Philippines, Papua New Guinea and Mexico. However, it should be noted that despite the high ore grades in Zaire and Zambia, mining and processing costs in those countries are high due to difficult geological structures and the metallurgical characteristics of the ore deposits.

On the basis of ore grades, therefore, it would appear that Canadian producers have a distinct competitive disadvantage. This, however, is only part of the story. The disadvantage of mining lower average copper ore grades is offset by the valuable coproducts and byproducts contained in many Canadian deposits.

There are essentially two kinds of copper orebodies in Canada — porphyry deposits found in British Columbia, which are mined by open-pit methods; and sulphide deposits found mostly in Manitoba, Ontario and Québec, which are mined by underground methods. The sulphide deposits contain significant quantities of gold, nickel, cobalt and zinc, and to a lesser extent, silver, the platinum group metals and lead. For some mining operations, the total value of coproducts and byproducts exceeds the value of the copper produced. The same, however, is not true for the porphyry copper deposits in British Columbia. These contain few coproducts and byproducts, though some deposits do contain significant quantities of molybdenum and gold and, to a lesser extent, silver. Because of this lower coproduction of metals, the porphyry deposits are more vulnerable to competitive pressures than the massive sulphide deposits.

The endowment of valuable coproducts and byproducts is, to a large extent, responsible for Canada's favourable cost position among world copper producers. In addition, this competitive position improved significantly in 1979 and 1980 with the sharp increase in precious metal prices, and the prices of cobalt and molybdenum. While these prices have since fallen, they still exceed the levels experienced during the 1950-78 period and are expected to continue to do so. Canadian producers also have derived advantages from superior exploration and processing technology, the availability of skilled manpower, and a more stable economic and political climate than in many less developed African or Latin American countries. All these advantages have worked to offset the drawback of lower ore grades.

Over the 1980s and 1990s, the average ore grade at Canadian mines is expected to fall more than those of our major competitors, thus increasing Canada's disadvantage on the basis of reserve availability and ore grade. Table 2 compares the average ore grade for total known reserves to those for existing producing mines, and indicates that the average grade of ore mined in Canada will fall by 11.4 per cent, compared to only 6.8 per cent for the world. Canada will have to enhance its comparative advantage in other areas to overcome this increasing disadvantage of lower ore grades.

Remoteness of mine location will continue to grow in importance as a factor determining competitiveness in the mineral industry. This is particularly true in Canada, where many major new mineral developments are likely to occur far from existing infrastructure and be subject to severe climatic conditions. In addition to higher infrastructure costs, unfavourable geographic location can mean longer development and preproduction phases because of the long distances from supply sources. The importance of infrastructure in relation to total development costs in Canada's North is more fully discussed in the chapter on *Infrastructure*. It is sufficient to emphasize here that infrastructure for a major mineral development in Canada's North can represent well over half the total capital costs of the project.

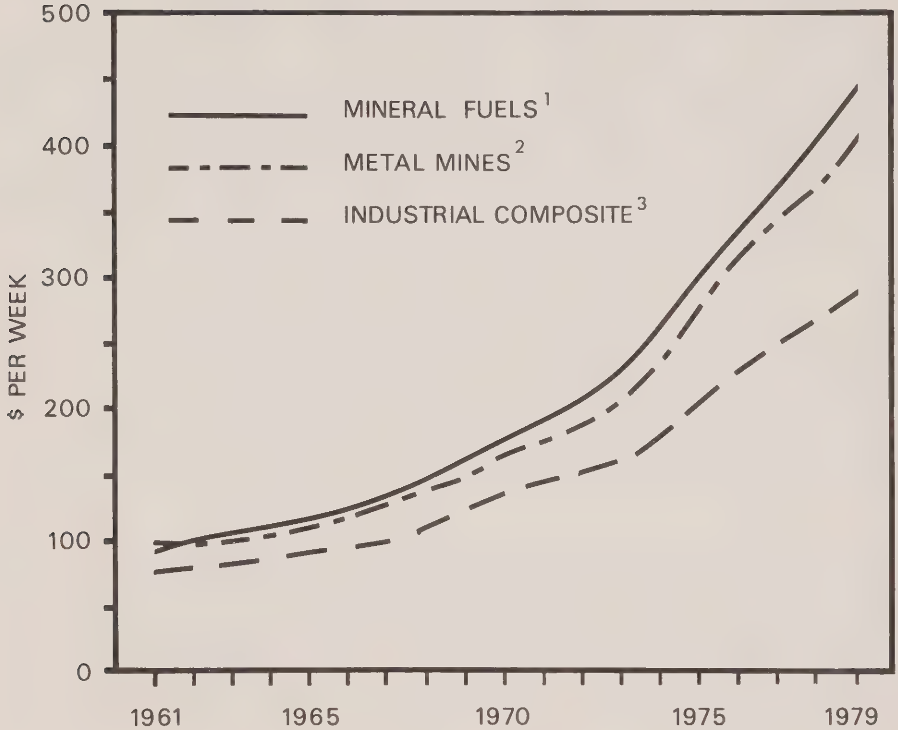
In contrast, some relatively unexplored or more richly endowed Third World countries might be able to develop deposits in future that will be more favourably located. This could happen in Chile, Peru and the Philippines. It is therefore likely that Canada will experience a comparative disadvantage in the years to come, as more and more of its developments take place in remote areas.

## Operating Costs

Labour is the single most important component of operating costs for Canadian mineral producers. While wages and salaries in the mineral sector have generally reflected wage developments in the rest of the economy, they have consistently exceeded the average for the total industrial sector, with the gap widening in recent years. Moreover, a gap has developed in labour earnings between the mineral sector and the oil and gas sector, where previously there

FIGURE 1

# AVERAGE WEEKLY EARNINGS IN CANADA




NOTE 1. Coal mines, crude petroleum and natural gas industry. 2. All metal mines industries including gold, uranium and iron mines. 3. Primary, secondary, tertiary industries.

SOURCE: Statistics Canada, Employment Earnings and Hours, Cat. No. 72-002

had been none. Figure 1 illustrates this by comparing average weekly earnings in Canada for mineral fuels, metal mines and the industrial composite.

Despite the recent gap between the mineral and energy sectors, it is clear from Figure 1 that wages and salaries in the mineral sector are being pulled upwards by the buoyant energy sector. This is not surprising, since the two sectors tend to compete for the same skilled workers in many areas of Canada, particularly in the West. The implications are significant — if wages

and salaries in the energy sector continue to rise very rapidly, the upward pressure on wages and salaries in the mineral sector will also continue. In the long run, this would adversely affect the competitive position of the Canadian mineral industry.

Due to lack of data it is not possible to compare the rate of wage increases in the Canadian mineral industry over the 1970s to those of Canada's major competitors on world mineral markets. An educated guess would be that the rates in Canada probably rose somewhat less rapidly, so that on balance, Canada has probably gained competitiveness on the wage front. This, however, has to be tempered with the realization that wage rates in many competing countries are less than an eighth or a quarter those in Canada.

Since the dramatic increase in world oil prices, energy costs have assumed great importance for all Canadian industries, including the mineral sector. Energy, as a component of cost, has made and will continue to make a positive contribution to the competitive position of the Canadian mineral industry during the 1980s. There may be periods when oil prices rise faster in Canada than elsewhere, but over the decade, oil prices will not exceed world prices, given that the Canadian price for "old" oil will not exceed 75 per cent of international prices. Moreover, the parity price of natural gas should decline. Furthermore, Canada is well endowed with other sources of energy, such as hydro power and coal, and has an excellent nuclear energy potential. The competitive edge on energy costs, however, will vary among mineral commodities — the more energy-intensive the commodity, the greater will be its competitive edge.

In the case of nickel production, Canada's energy advantage will be two-fold. Canadian nickel producers will not only benefit from lower domestic energy prices, but also because the sulphide nickel ores mined in Canada require considerably less energy to process — one quarter or less — than the lateritic ores mined by many of Canada's competitors. It is estimated that for every $1 per barrel increase in the price of oil, the cost of producing one pound of nickel from lateritic ores increases by 5¢ (U.S.). This means that since 1973, energy costs at some lateritic operations have risen by more than $1.50 per pound of nickel, compared to only about 15¢ per pound for sulphide ores. For some lateritic nickel producers, energy costs now represent more than 50 per cent of total costs.

The competitive position of Canadian mineral producers is also particularly sensitive to fluctuations in the exchange rate of the Canadian dollar with consuming-country currencies. A depreciation of the Canadian dollar has an impact equivalent to either an increase in realized prices, denominated in Canadian dollars, or a decrease in production costs, denoted in the foreign currency — depreciation of the dollar improves competitive position.

The Canada - United States exchange rate is particularly relevant because prices for internationally traded minerals are usually stated in U.S. currency, and also because the United States represents a significant market for Canada's mineral exports. Between 1976 and 1981, the drop in value of the Canadian dollar was more than 20 per cent, while the devaluation of the dollar relative to strong currencies like the Japanese yen or the German mark was even more pronounced. This devaluation significantly enhanced the industry's competitive position and profitability.

The importance of a change in the value of the Canadian dollar is illustrated in Table 3, where the results clearly show the significance of changes in the exchange rate and output price on the rate-of-return on equity for metal mines. A 10 per cent rise in the exchange rate reduces the rate-of-return from 24.7 to 18.9 per cent. This estimate is based on the assumption that 80 per cent of revenues are derived from export sales and that the domestic price does not respond to the change in the exchange rate. If the domestic price did respond to a change in the exchange rate, as would likely be the case for commodities sold on international markets, the impact on the rate-of-return would be analogous to a change in the price of output. Therefore, the reduction in the rate-of-return could conceivably be up to 7.4 percentage points, giving a

**Table 3. Impact on the after-tax rate-of-return on equity for metal mines under various scenarios (1979)**

| | Rate-of-return | Difference from actual rate-of-return |
|---|---|---|
| | (%) | |
| Actual rate-of-return | 24.7 | – |
| 10% rise in the exchange rate | 18.9 | 5.8 |
| 10% fall in the price of output | 17.3 | 7.4 |
| 10% rise in the cost of labour, materials and all other operating expenses (except energy) | 20.3 | 4.4 |
| 10% surtax on total taxes payable | 23.9 | 0.8 |
| 10% rise in the cost of fuel and electricity | 23.2 | 1.5 |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

rate-of-return of 17.3 per cent rather than 24.7 per cent. Both a rise in the cost of labour, materials and other operating expenses (excluding energy), and in energy costs, have a smaller impact on the rate-of-return though the impact is still significant. Moreover, while a 10 per cent change in wages for any given year may be quite reasonable, this is not the case for energy prices — while the sensitivity of a change in energy prices may be modest, the fact that energy prices have risen and will continue to rise rapidly can overshadow the impact on profitability of changes in other factors.

The results in Table 3 also indicate that taxes have a much smaller impact upon profitability than do prices, the exchange rate and operating costs. However, taxes are unique in that they are amenable to revision. In fact, both income and mining taxation of resource income underwent significant changes in Canada during the 1970s. The net effect was to significantly increase the overall tax burden on the mineral industry (see *Taxation and Incentives*). Everything else being equal, this increase reduced the competitive position of the Canadian mineral industry. The impact of taxation on competitive position should not be underestimated despite the low sensitivity of profitability to changes in taxes as outlined in Table 3. Taxation increases reduce cash flows and, hence, impair the ability to reinvest and lessen the incentive to invest.

In addition to the foregoing, there are other factors that can affect the mineral industry's competitive position such as technological developments, environmental protection and trade barriers. As indicated earlier, Canada has had an edge in terms of exploration, mining and processing technology compared to many other mineral producers. But to remain competitive, Canada will have to stay in the forefront of technology development, and new technology must be continuously adopted by industry (see *Mineral Science and Technology*).

Up to now, environmental costs have not been too onerous. But the introduction of more stringent environmental standards, notably to reduce sulphur dioxide emissions, could add appreciably to production costs for some existing operations. For a more detailed discussion of this issue see the chapter on *Environment*.

Regarding foreign tariffs and other trade barriers, the outlook is not particularly encouraging. Despite continued efforts by the Government of Canada at international forums to have these barriers reduced, Canadian mineral exports face, and are likely to continue to face, a system of escalating tariffs where the level of protection increases with the degree of

mineral processing. While such barriers on the whole have not been increased in the 1970s, they have not been decreased either (see *International Marketing of Minerals*).

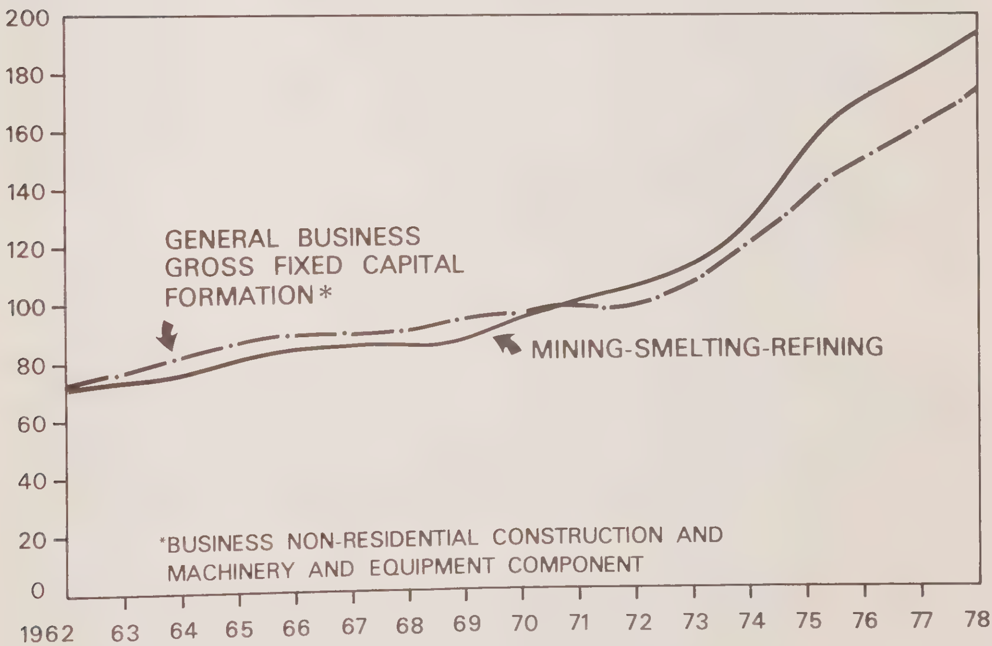
## Capital Costs

Next to the soaring increase in the price of crude oil, the most significant development affecting mining in the 1970s was the extraordinary rise in the cost of financing new projects and the increase in capital costs. The growth in the cost of funding new facilities or expanding existing facilities reflected the general rise in world inflation. However, the cost of capital goods for the mineral industry increased at a faster pace in the 1970s than capital goods prices for other sectors (Figure 2).

The large increase in the capital cost of bringing new capacity into production during the 1970s can be illustrated by examining the experience of the nickel industry. Table 4 shows, for various projects, the investment per pound of annual nickel capacity required to bring new capacity into production over time. In the 1950s and 1960s, each pound of nickel extracted required a capital investment of $2 to $3 per pound of annual capacity, denoted in current dollars. By the early 1970s, capital costs had increased to between $3 and $4 per pound; by the

FIGURE 2

CAPITAL GOODS PRICE INDEXES IN CANADA
(1971=100)




SOURCE: Resource Strategy and Economic Analysis Branch, EMR

late 1970s costs had climbed to between $9 and $12 per pound. In real terms and in relation to the price of nickel, capital costs did not rise during the first half of the 1970s but did experience a very dramatic rise in the second half of the 1970s. The increase in nickel prices during the latter period clearly did not keep up with capital cost escalation.

**Table 4. Capital costs for integrated nickel operations**

| | Year of completion | Cost per pound of annual nickel capacity: Current | Constant 1971* | Ratio of current cost to nickel price† | Nickel products |
|---|---|---|---|---|---|
| | | ($) | | | |
| Sherritt-Gordon (Lynn Lake and Fort Saskatchewan) | 1956 | 2.76 (1.80)‡ | 4.10 (2.67) | 4.2 (2.8) | Briquettes, powders and coinage blanks |
| Inco (Thompson, Manitoba) | 1961 | 2.40 | 3.31 | 3.1 | Electrolytic nickel |
| Falconbridge Nickel Mines (Dominican Republic) | 1971 | 2.86 | 2.86 | 2.2 | Ferronickel |
| Bamanquato Concessions (Botswana, Africa) | 1973 | 6.25 (3.25) | 5.45 (2.83) | 4.1 (2.1) | Nickel-copper matte |
| Marinduque (Philippines) | 1974 | 3.60 | 2.75 | 2.1 | Briquettes and powders |
| Inco, Eximbal (Guatemala) | 1977 | 9.52 | 5.65 | 4.29 | Nickel matte |
| Inco, P.T. International Nickel (Indonesia) | 1978 | 11.56 | 6.32 | 5.72 | Nickel matte |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

* Calculated using the Canadian Gross National Expenditure price deflator (1971 = 100).

† Price—quoted list price for electrolytic nickel.

‡ Figures in parentheses denote cost per pound of nickel-copper capacity. These are provided for installations producing significant quantities of copper in addition to nickel.

The rapid escalation in capital goods prices for the mineral industry in Canada is partly related to high demand in the energy sector — e.g. for tar-sands development — for capital goods common to both industries. It follows that such energy projects could continue to create problems for the Canadian mining sector in the 1980s. Although the price escalation here eventually could not proceed more rapidly than in other countries for a given exchange rate level, it could do so in the short run if demand pressures from the energy sector for goods common to both industries were to accelerate. This could affect the timing of new developments in Canada and their competitive position.

Also, because the mineral industry in Canada is more capital-intensive than in the less developed mineral-producing countries, rapid capital cost escalation would have a greater impact here than in Chile, for example, where the production technology is more labour intensive. In essence, rapid cost escalation could offset somewhat Canada's technological advantage if it were to persist over a long period of time.

## Overall Competitive Position for Nickel, Copper and Zinc

On the basis of the foregoing analysis of major factors affecting competitiveness in the mineral industry, Canada's position with regard to three commodities — nickel, copper and zinc — is now examined. These were selected because they are major export commodities and, in a general sense, are representative of Canada's overall competitive standing in world markets. It should be noted, however, that mineral markets are not all alike and that Canada's competitive position differs for each and every commodity.

There are no easily available information sources from which to compare production costs of various firms or producing countries. Most data must be extracted from corporate financial statements, which are highly aggregate. Also, most firms are multiproduct operations — the costs of producing coproducts and byproducts are usually lumped with those of the mineral of principal interest. All cost comparisons, therefore, must be estimates based on the assumptions, methodology and adjustments required to obtain comparable figures.

Table 5 compares the competitive position of six world nickel producers, presenting indices of unit cost of production for 1980. It is quite evident that Canadian unit production costs in 1980 were lower than those for all other countries. This is due to a number of factors, the most important of which is the type of ore deposits mined in Canada. Sulphide ores, as has been shown, contain many valuable coproducts and byproducts and require less energy to process than the lateritic ores mined by many foreign producers.

Although labour, as already noted, is the major cost component for Canadian operations, these higher labour costs are more than offset by the energy advantage and superior ore quality. For example, in addition to nickel, the Sudbury ores mined by Inco and Falconbridge contain important amounts of copper, gold, silver, platinum, palladium, rhodium, ruthenium, iridium and osmium, and of cobalt, selenium, tellurium, iron and sulphur.

Several lateritic nickel producers are currently considering converting their operations from oil to cheaper forms of energy such as coal and hydro. This would make these operations

**Table 5. Index of unit cost of nickel production for selected countries* (index: total cash cost for Canada in 1980 = 100)**

| | Canada | Australia | Dominican Republic | New Caledonia | Philippines | Indonesia |
|---|---|---|---|---|---|---|
| Cash operating cost | | | | | | |
| Energy | 10 | 42 | 74 | 66 | 86 | 33 |
| Labour | 66 | 37 | 18 | 52 | 4 | 6 |
| Material and supplies | 23 | 26 | 26 | 26 | 28 | 22 |
| Overhead and other | 13 | 10 | 13 | 14 | 3 | 8 |
| Total | 112 | 115 | 131 | 158 | 121 | 69 |
| Further processing† | – | 7 | – | 10 | – | 20 |
| Less byproduct production cost‡ | (27) | (5) | – | (3) | (5) | – |
| Total cash operating cost | 85 | 117 | 131 | 165 | 116 | 89 |
| Interest expense | 15 | 25 | 11 | 20 | 50 | 44 |
| Total cash cost | 100 | 142 | 142 | 185 | 166 | 133 |
| Rank | 1 | 3 | 3 | 6 | 5 | 2 |

SOURCE: Ilmar J. Martens and Associates, Inc.

* Defined as net cash costs and excludes depreciation and amortization costs as well as taxes payable.

† The additional cost allocated to companies selling nickel in a form that requires further refining.

‡ Coproduct and byproduct production costs.

more cost competitive in the years ahead, but clearly not enough to significantly offset the favourable position of Canadian producers. Energy costs per pound of nickel produced in Canada will continue to be significantly lower than in most foreign countries, and Canadian producers will continue to mine and process ores that are more valuable in terms of coproducts and byproducts.

This currently strong position could be reduced over the longer term by a combination of factors: a decline in world oil prices; the development of less energy-consuming processes for lateritic ores; a significant increase in labour wage rates in Canada; a significant appreciation in the value of the Canadian dollar relative to foreign currencies. But barring significant developments on a number of these fronts, the competitive position of Canadian nickel producers should continue to remain strong in the years ahead.

The competitive position of Canadian copper producers in 1973, 1976 and 1979 is shown in Table 6. As can be seen, Canadian production costs over the period were among the lowest in the world. In 1979, only Australia, Papua New Guinea and Zaire had lower costs than Canada. In fact, according to some analysts, Zaire's costs for 1979 may be understated; Zaire's average costs have historically exceeded those in Canada.

**Table 6. Index of unit cost of copper production for selected countries* (index: Canada 1979 = 100)**

| | 1973 | 1976 | 1979 | Rank (1979) |
|---|---|---|---|---|
| Australia | 138 | 69 | 69 | 2 |
| Canada | 86 | 45 | 100 | 4 |
| Chile | 179 | 138 | 131 | 6 |
| Peru | 145 | 145 | 134p | 7 |
| Philippines | 138 | 158 | 152p | 8 |
| Papua New Guinea | 72 | 117 | 59 | 1 |
| South Africa | 90 | 86 | 114 | 5 |
| United States | 134 | 176 | 193 | 10 |
| Zaire | 97 | 117 | 86p | 3 |
| Zambia | 141 | 183 | 179 | 9 |

SOURCE: Stewart, R. E., *The Competitive Position of Chilean Copper Mines During the 1980's*, presented at the Copper Porphyry Congress, Santiago, Chile, November, 1980.

* Defined as net cash costs which is equal to total production costs less the value of coproducts and byproducts. Total production costs include all mine and mill operating expenses, transportation, marketing, smelting and refining charges, general administration interest charges and any royalty or taxes based on production or sales. Excluded from production costs are any taxes based on profits or income, depreciation or depletion charges, write offs and any research and exploration expenses.

p—provisional.

Again, Canada's cost advantage stems primarily from the wide-spread coproduction of other metals, with a much lower degree of coproduction at mines in other copper-producing countries. This is illustrated in Table 7. Canada's strong competitive position is due to the coproduction of nickel, cobalt, gold, silver, molybdenum and lead. Australia's strong position stems from the coproduction of zinc, lead, gold and silver. In Papua New Guinea, the coproduction of significant quantities of gold, and to a lesser extent silver, is responsible for that country's strong position in the copper market.

It must be pointed out that the estimated indices of unit cost in Table 6 are averages, and mask the high degree of cost variability among Canadian mines. The large-scale, low-grade open-pit porphyry copper mines in British Columbia are the least cost competitive and, therefore, the most vulnerable to pressures from abroad. On the other hand, the nickel-copper and copper-zinc mines located mostly in Québec, Ontario and Manitoba have, in general, a rela-

**Table 7. Relative importance of coproduct and byproduct metals to major copper producers expressed as a percentage of total production costs**

| | 1973 | 1979 |
|---|---|---|
| | (%) | |
| Australia | 47 | 82 |
| Canada | 78 | 82 |
| Chile | 6 | 22 |
| Papua New Guinea | 48 | 76 |
| Peru | 10 | 28 |
| Philippines | 23 | 32 |
| South Africa | 31 | 49 |
| United States | 29 | 41 |
| Zaire | 26 | 66 |
| Zambia | 7 | 19 |

SOURCE: Stewart, R. E., *The Competitive Position of Chilean Copper Mines During the 1980's*, presented at the Copper Porphyry Congress, Santiago, Chile, November 1980.

**Table 8. Competitive position of major zinc producing countries in 1978 (index: Canada = 100)**

| | Index of unit cost of production* | Rank |
|---|---|---|
| Australia | 56 | 3 |
| Canada | 100 | 5 |
| West Germany | 175 | 9 |
| Ireland | 119 | 7 |
| Japan | 137 | 8 |
| Mexico | 63 | 4 |
| Peru | 0 | 1 |
| South Africa | 113 | 6 |
| Sweden | 175 | 9 |
| United States | 38 | 2 |
| Non-Communist world (average) | 106 | – |

SOURCE: Mackenzie, B., *Canada's Competitive Position in Copper and Zinc Markets*, Centre for Resource Studies, Queen's University, 1979, p. 34.

* Defined as total production cost less the value of coproducts and byproducts. Total production costs include all the operating and overhead expenses of the mine and mill, transportation, smelting and refining charges, marketing expenses, general administrative overhead, and royalty payments that are based on production or sales revenue. Excluded from production costs are taxes based on income or profit, depletion allowances, debt repayments and exploration expenses.

tively strong competitive position because of significant coproduction of base and precious metals.

Table 8 shows the competitive position of the non-Communist world's 10 largest zinc-producing countries for 1978. It can be seen that production costs in Canada are very close to the world average. As such, Canada's competitive position in international zinc markets, though relatively good, is not nearly as favourable as for nickel and copper. In 1978, Australia, Mexico, Peru and the United States had lower costs than Canada. The lower U.S. cost, however, is due partly to the exclusion of many high-cost operations that were closed prior to 1978.

As in the case of copper, the competitive position of Canadian zinc producers varies depending on the type of deposit mined — on average, producers mining copper-zinc deposits

have lower costs than those mining zinc-lead deposits. This, in large measure, reflects the higher value of coproducts and byproducts associated with copper-zinc deposits. In other words, the zinc-lead deposits in British Columbia, the Territories and New Brunswick are more vulnerable to foreign competitive pressures than the copper-zinc deposits located mainly in central Canada.

## Summary

The major factors affecting the competitive position of the Canadian mineral industry, relative to competitors, are summarized below, together with their impact on the industry during the 1970s and their expected impact through the 1980s:

| | Impact on competitiveness | |
|---|---|---|
| Factors | 1970s | 1980s |
| Ore grade | Slightly negative | Slightly negative |
| Type of ore (e.g. coproducts and byproducts) | Strongly positive | Strongly positive |
| Location | Slightly negative | Moderately negative |
| Capital costs | Neutral | Slightly negative |
| Labour costs | Strongly negative but with improving trend | Strongly negative |
| Energy costs | Strongly positive since 1973 | Moderately positive |
| Exchange rate | Strongly positive since 1976 | Strongly positive in the absence of appreciation |
| Taxation | Slightly negative | Slightly negative |
| Technology | Strongly positive | Strongly positive |
| Environment | Neutral | Slightly negative |
| Tariffs and trade barriers | Strongly negative for processed minerals | Strongly negative for processed minerals |

# Taxation and Incentives

## Introduction

Taxation of resource income underwent significant changes in Canada during the 1970s. January 1, 1972, marked the beginning of a proposed five-year transition period introducing a major reform of the federal tax system. Most of the provisions of the reform, however, were introduced ahead of schedule in 1974 because of tax actions by certain provinces.

Before 1974, mining was subject to the general federal rules governing corporate income, but the mining industry was given some special incentives. Provincial and territorial mining taxes and/or royalties were deductible in calculating federal income tax. New mines were granted a three-year exemption from taxation, and write-offs for development, capital and other costs were deferred beyond this period. Capital cost allowances and the provisions for the deductibility of exploration and development expenses were relatively generous. In addition, mining income to the prime metal stage was subject to automatic percentage depletion which, in effect, exempted one third of otherwise taxable income in perpetuity. Also, prior to 1972, prospectors and grubstakers (financial backers) were exempt from income tax on the gains they realized from the sale of mining properties; these gains became subject to tax in 1972.

However, in late 1973 and early 1974, some provinces significantly increased their mining taxes and/or royalties in response to a cyclical upturn in metal prices. As these levies were deductible for federal tax purposes, the changes meant a significant reduction in the federal tax base.

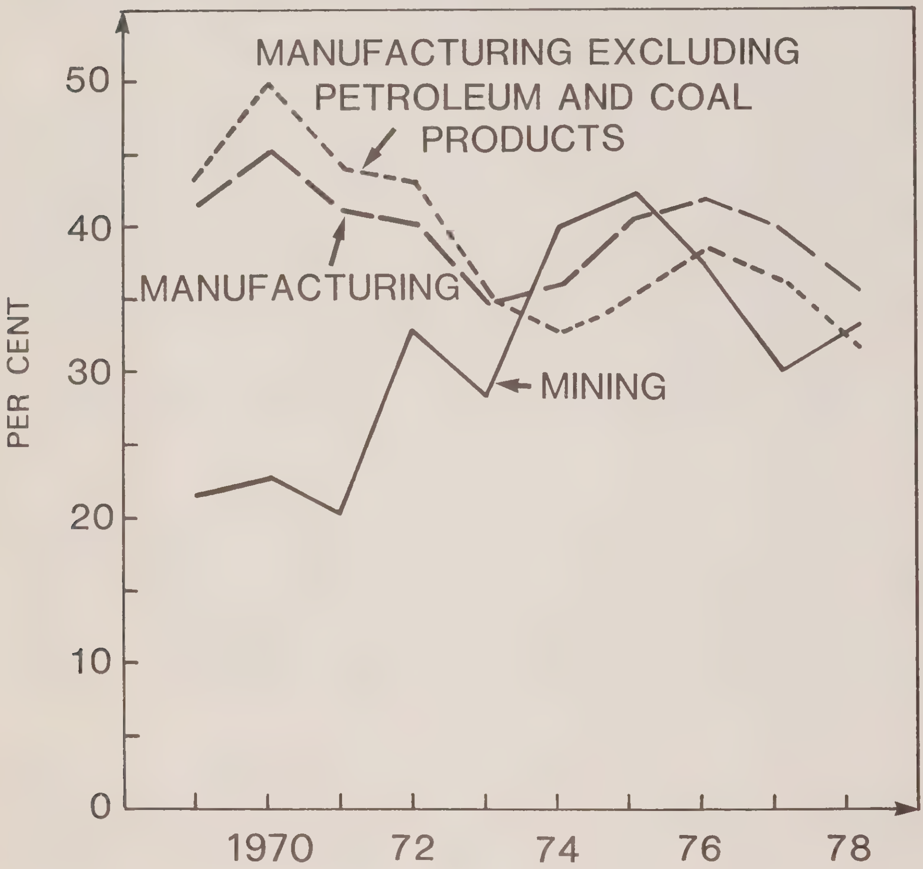
In accordance with the tax reform schedule, the three-year federal exemption for new mines was terminated at the end of 1973. To partially offset this, an accelerated capital cost allowance program was introduced. Effective May 7, 1974, provincial and territorial production levies — mining taxes, royalties, etc. — were no longer deductible in calculating federal income taxes. At the same time, the automatic depletion allowance was replaced by a system wherein the benefits had to be earned through expenditures. Development costs, including the cash acquisition costs of mining properties, became deductible at 30 per cent per year on a declining balance basis instead of to the extent of income. The federal corporate tax rate for mining income was established at 25 per cent.

On January 1, 1976, a resource allowance deduction, equal to 25 per cent of production profits, was introduced for federal tax purposes. At the same time, the federal corporate tax rate was increased from 25 to 36 per cent, the general corporate rate. In late 1978, the write-off rate for development costs for new mines was restored to 100 per cent and was treated the same way as exploration costs. The acquisition cost of mining properties remained deductible at 30 per cent per year on a declining balance basis.

The federal tax reform and the provincial changes significantly increased the tax burden on the mineral industry and altered the federal-provincial share of total tax revenue. The overall effective tax rate on mining — provincial and federal income taxes plus mining taxes and royalties, as a percentage of before-tax book income — increased from 21.5 per cent in 1969 to 41.8 per cent in 1975 (Figure 1). Since 1975, the rate has dropped to 37.3 per cent in 1976, 30.2 per cent in 1977 and an estimated 32.9 per cent in 1978. This drop has been due mainly to reduced profitability and adjustments to the tax systems. Further adjustments since 1978,

FIGURE 1

TOTAL FEDERAL AND PROVINCIAL TAXES AS A PERCENTAGE OF BOOK INCOME BEFORE TAXES




SOURCE: Based on Statistics Canada, Corporation Financial Statistics, Cat. No. 61-207, and Corporation Taxation Statistics, Cat. No. 61-208, various issues

notably by some provinces, should have further reduced the effective tax rate on mining. The current variability of mining tax and royalty systems among provinces is illustrated by Table 1.

**Table 1. Comparison of total production levies in various jurisdictions over 20 years of operation for two hypothetical metal mines under 1980 tax structures (project basis)**

| | DEF mine model | CBA mine model |
|---|---|---|
| | ($ millions)* | |
| Newfoundland | 2.3 | 102.4 |
| Nova Scotia | 4.2 | 94.8 |
| New Brunswick | 3.0 | 132.7 |
| Québec | 0.7 | 150.5 |
| Ontario | 1.2 | 160.0 |
| Manitoba | 1.1 | 97.6 |
| Saskatchewan | 1.9 | 78.9 |
| British Columbia | 1.9 | 104.7 |
| Northwest Territories | 0.4 | 39.4 |
| Yukon | 0.9 | 46.6 |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

*Constant 1980$.

DEF—marginally profitable, medium size, mine-mill operation.

CBA—profitable, large, mine-mill operation.

Taking all factors into consideration, the mining industry does not appear to be unfavourably treated compared to other sectors of the Canadian economy. The impact of the tax changes was to bring the overall industry burden of tax — federal and provincial — to a level approaching that for manufacturing. In fact, except for 1974 and 1975, the effective tax rate on mining has been lower than that for total manufacturing (Figure 1). Effective tax rates in sectors other than manufacturing are also quite comparable to the tax rate on mining.

The federal tax increase on the mining industry was relatively modest compared to the significant provincial increase (Figures 2 and 3). Federal taxes as a percentage of book income before taxes increased from 10.0 per cent in 1969 to 17.3 per cent in 1974 and then fell back to 12.4 per cent in 1978. On the other hand, provincial income taxes plus mining taxes and royalties, as a percentage of pretax book income, rose from 11.6 per cent in 1969 to 27.3 per cent in 1975 and then fell back to 20.5 per cent in 1978. The net effect was that the federal share of total taxation revenue from the mining industry decreased from 46.1 per cent in 1969 to 37.8 per cent in 1978.

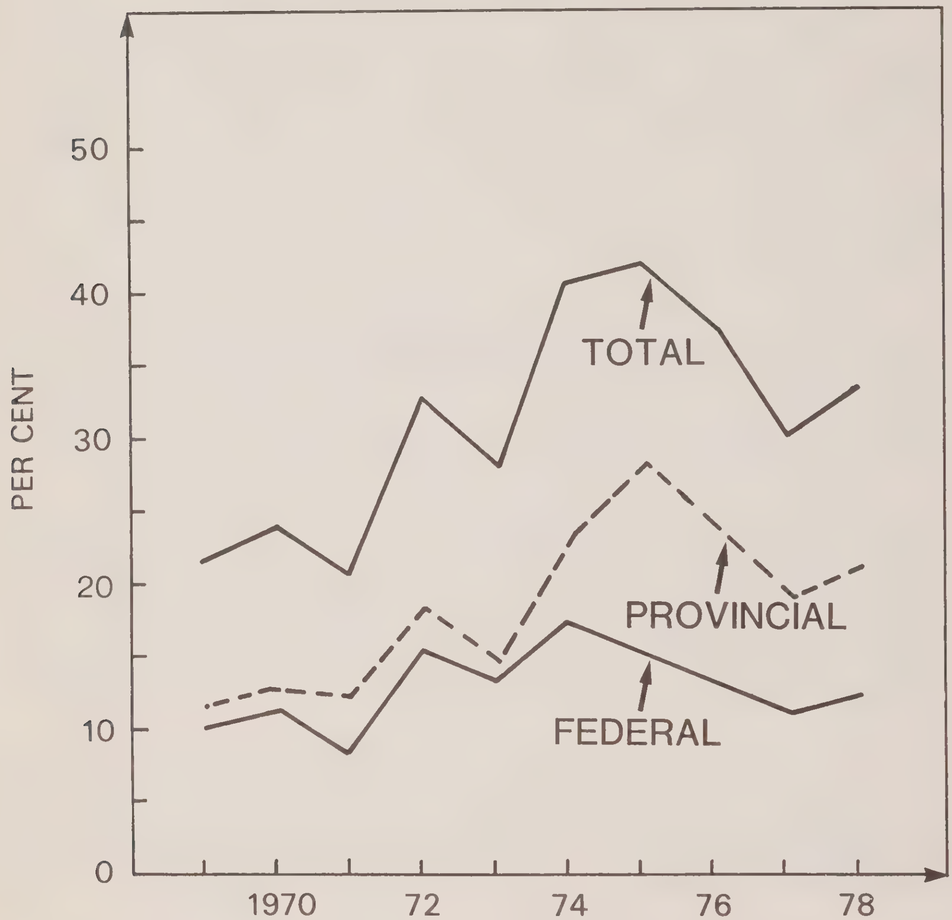
The provincial tax increases were, to some extent, made possible because the federal *Income Tax Act* treated mining income more favourably than income from other sectors, such as manufacturing. In essence, the favourable federal tax treatment made it possible for the provinces to extract more revenue from the industry. The effective federal income tax rate for mining was 10.0 per cent in 1969, 14.5 per cent in 1975 and 12.4 per cent in 1978 (Figure 4). This compares with 27.3, 19.9 and 15.7 per cent respectively for manufacturing.

## Overall Level of Taxation

While the overall tax burden on the mining sector is no greater than the burden on manufacturing, it is often remarked that the mining sector should be treated more leniently because the risks are greater and so the rates-of-return should be higher. Conversely, it is frequently argued that the mining sector should be taxed more heavily on the grounds that mining generates "economic rents" — a surplus of profits over and above those necessary to induce enterprises to continue to operate and invest.

FIGURE 2

# FEDERAL AND PROVINCIAL TAXES AS A PERCENTAGE OF BOOK INCOME BEFORE TAXES FOR THE MINING INDUSTRY



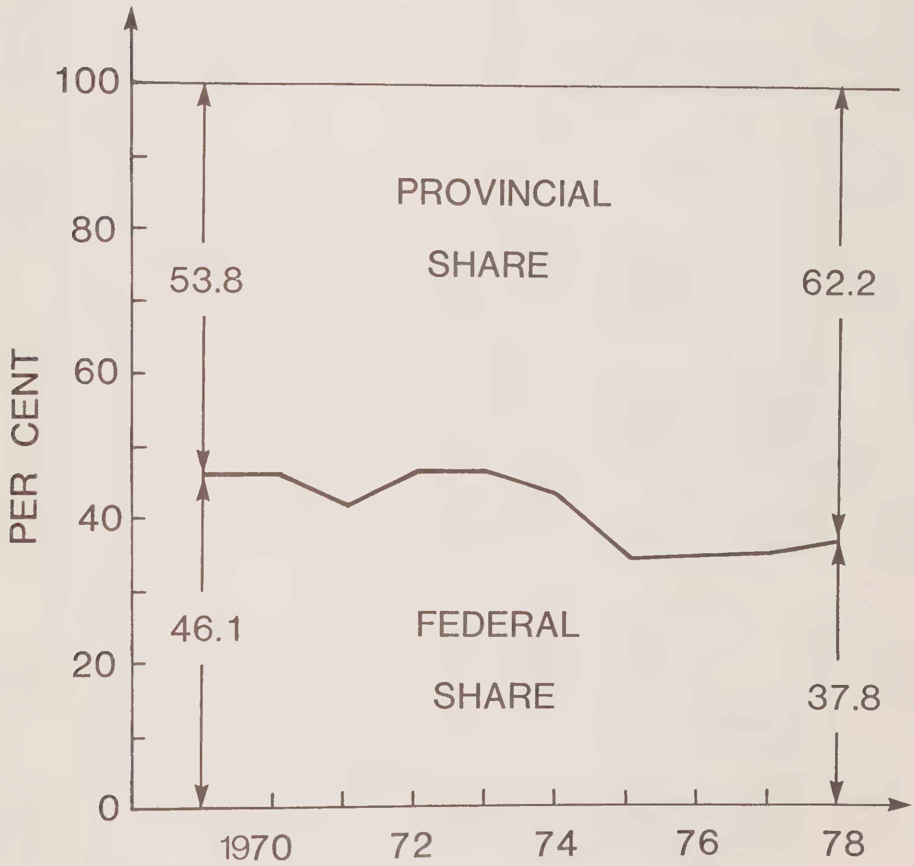

SOURCE: Based on Statistics Canada, Corporation Financial Statistics, Cat.No. 61-207; and Corporation Taxation Statistics, Cat.No. 61-208, various issues

With regard to the former point of view, the principal risk in mining is that associated with exploration and its uncertainties — it is argued that at this stage investment is undertaken with

a rather low probability that this expenditure will result in a mining venture or even a saleable property of any significant value. A second facet of this risk is the uncertain time lag between exploration effort and ultimate production. In addition, it is often said that the mining industry is subjected to unusual price cyclicality and, because of this, the risks inherent in mining are larger than for other sectors.

FIGURE 3

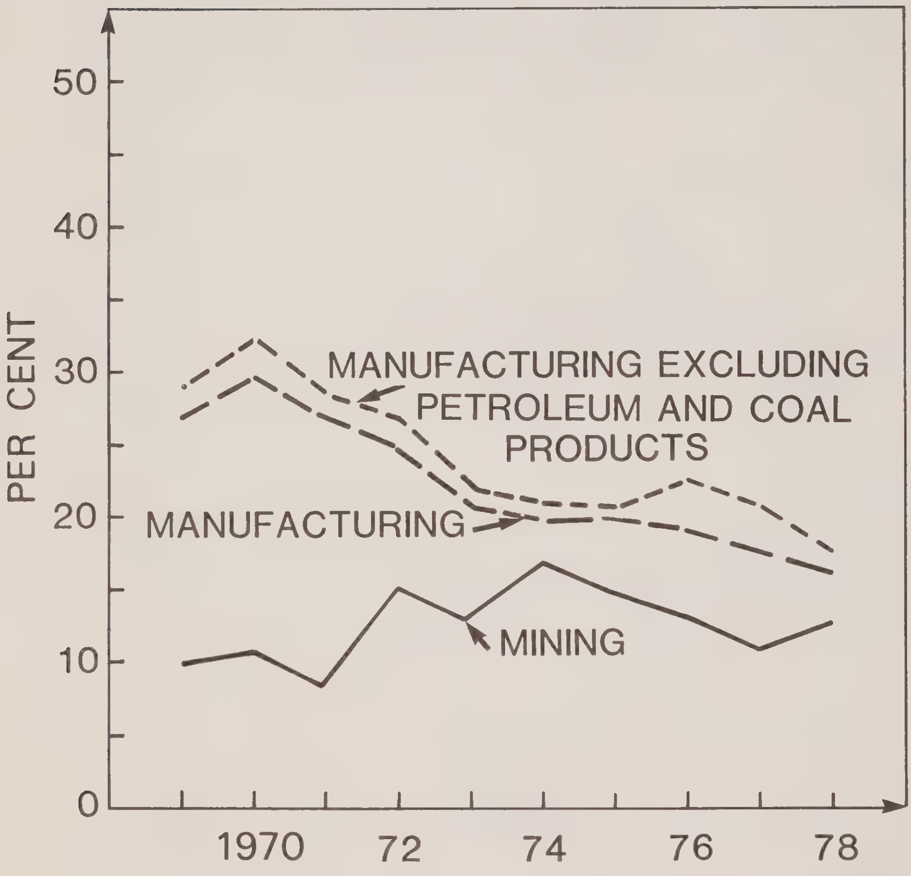
FEDERAL-PROVINCIAL SHARE OF TAXATION REVENUES FROM THE MINING INDUSTRY




**SOURCE:** Based on Statistics Canada, Corporation Financial Statistics, Cat. No. 61-207; and Corporation Taxation Statistics, Cat. No. 61-208, various issues

FIGURE 4

## FEDERAL INCOME TAXES AS A PERCENTAGE OF BOOK INCOME BEFORE TAXES




SOURCE: Based on Statistics Canada, Corporation Financial Statistics, Cat. No. 61-207; and Corporation Taxation Statistics, Cat. No. 61-208, various issues

In fact, whether mining is more risky than other industries is far from clear. First of all, exploration risks are not altogether unlike the risks associated with investment in research and development. Second, exploration risks can be reduced through pooling — a company can

diversify its exploration program or participate in a number of joint ventures rather than channel its total exploration budget into one particular venture. However, pooling of risks is not always possible for junior exploration companies because of their small size and lack of finances. But for large companies pooling is possible and highly desirable. It is therefore debatable whether exploration risks are particularly high for large companies.

Also, tax treatment of exploration expenditures is very attractive — they usually can be deducted at a rate of 100 per cent for federal and provincial income and mining taxation. They also qualify for earned depletion allowances for most income tax purposes. In addition, these expenditures qualify for additional preferred treatment under the tax systems of some provinces. In many cases, the after-tax cost of exploration to a large company can be 25¢ or less per dollar expended. The risks to large companies are therefore small, given the incentives.

However, junior mining companies may not be able to take full advantage of tax incentives. If a company has no income, it cannot realize tax benefits on exploration expenditures until a mineable mineral deposit is discovered and income accrues to the company from it. If the junior mining company has no resource income but does have other income, exploration expenditures can be written off at a rate of 100 per cent, but the company is still unable to take advantage of the related earned depletion. In the absence of any income, the expenditures cannot be deducted at all.

Regarding cyclicality, the *1978 Federal-Provincial Resource Taxation Review* found that profits in the mining industries have generally been more variable than in other sectors. But the Review added that for larger firms over the long term, any associated risk due to cyclicality is offset by higher rates-of-return. It concluded, however, that this was not the case for small firms.

To summarize, the evidence suggests that exploration and cyclical risks are small for large firms, but may be large indeed for smaller companies. The risk to small firms may be large because their participation in a limited number of exploration activities and their limited cash flow are below the threshold at which risk aversion can be effectively practiced.

As in the case of risk, the issue of economic rents is highly controversial and the evidence far from clear. Furthermore, it is not clear how, from the standpoint of equity, these rents — assuming they exist — should be distributed among the private sector and the two senior levels of government. While most mining enterprises enjoy "windfall rents" when sudden increases in demand run up against highly price-inelastic short-run supplies, these do not constitute an appropriate tax base because they are counterbalanced by losses or low profits in the low-price phase of the mineral price cycle.

In those few sectors of mining where the structure of the international industry is highly oligopolistic, there may be some element of "monopoly rent". These rents, however, are usually difficult to calculate, especially when oligopoly power is not fully exercised because the established enterprises wish to prevent the entry of new organizations into the industry. Hence, monopoly rents are also not an appropriate tax base from which to extract revenues.

"Scarcity rent" is an important type of rent that occurs when mineral prices are forced upwards, when demand exceeds supply or the rate of demand growth continuously exceeds the rate of extraction for mineral ores that are genuinely scarce. Few minerals produced and exported by Canada fit this category, as global endowments are generous and long-run price elasticities are relatively high. But gold and other precious metals are exceptional cases where scarcity rents may exist.

A further type — "differential rent" — arises when particular enterprises or subsectors enjoy advantages such as a high ore grade, precious metal byproducts or favourable location. Finally, specific production factors, such as technological expertise, managerial abilities or

entrepreneurial skills, may be fixed and immobile in the short run, conferring a "quasi-rent" upon the enterprise.

If a tax to capture rents is deemed desirable it should, at most, be applied to tap scarcity and differential rents. Quasi-rents probably would not constitute an appropriate tax base due to their short-run nature. While a tax to capture both scarcity and differential rents may be theoretically appealing, the difficulty is that they cannot be appropriately taxed by an administratively simple and universally applied scheme. The tax would have to be company-specific or even perhaps site-specific and profit related, such as a rate-of-return.

It definitely would be inappropriate to impose an across-the-board tax, such as an increase in federal or provincial income tax rates, to extract economic rents. Such a tax could potentially harm important sectors of the industry, reducing the incentive to invest and accelerating mine shutdowns by marginal producers. The most vulnerable producers to a significant across-the-board tax to capture economic rents would be the large, relatively marginal, porphyry-type copper-based operations in British Columbia, and the iron ore producers in Québec and Newfoundland. Base-metal producers in Québec, Ontario and Manitoba would likely be the least affected by such a tax. In some cases, like the potash industry in Saskatchewan, producers could be subjected to hardship, not because of the absence of rents but because rents already are being captured.

It cannot be emphasized too strongly that the international and domestic markets for minerals differ fundamentally from those for petroleum products. Despite their great heterogeneity, mineral markets share a most important commonality, the absence of large monopoly and scarcity rents, in contrast to the markets for energy products such as petroleum and natural gas. As a result of this difference, the "rent" in the oil and gas sector that can and should be tapped by a form of tax far exceeds that available from the sale of most mineral resources. Total federal and provincial income taxes, including mining taxes and royalties, collected from the mining industry in 1978 amounted to $588.5 million, compared to $4.09 billion for the oil and gas sector.

To summarize, while differential and scarcity rents accrue to mineral producers, these are not widespread and are generally low, especially when compared to rents in the oil and gas sector. Furthermore, while theoretically appealing, these rents cannot be appropriately tapped by an administratively simple and universally-applied scheme and at the same time meet the objectives of equity and economic efficiency. To tap these rents, new tax structures would be needed that are company- or site-specific, and related to profitability.

## Federal-Provincial Division of Mining Tax Revenues

As noted earlier, the tax revenues that are and can be extracted from the mining industry are small compared to those from the oil and gas sector. A redistribution of taxes from the mining sector between the federal and provincial governments would increase federal revenues by no more than $50 to $100 million, compared to billions of dollars in the case of oil and gas. For example, a 50/50 federal-provincial split in mining tax revenues in 1975 rather than the actual 35/65 split would have meant an increase in federal revenues of $79 million. In 1978, the increase would have been in the neighbourhood of $72 million. This is very small compared to the stakes in the oil and gas sector, where a 50/50 split rather than the 19/81 split would have increased federal revenues by well over $1.2 billion in 1978 and by larger amounts in subsequent years. In addition, it should be noted that mineral revenues are more dispersed across the country and, therefore, cause less regional inequality and give rise to lesser equalization payments than oil and gas revenues.

During the federal reform of income taxation and the concomitant increase in provincial production levies, a conflict developed between the provinces and the federal government, with the latter concerned about the erosion of its tax base. The conflict centred on the deductibility of provincial levies though it was not confined to this issue. This conflict was resolved in 1978 by an unwritten understanding between federal-provincial finance and resource ministers, to the effect that no government would move into a mineral tax area vacated by the other level of government. The circumstances have not changed appreciably since 1978, so that no major review of taxation of the mineral sector is necessary at this time.

Therefore, initiatives to review or reverse the decline in the federal share of tax revenues that occurred in the 1970s are not desirable at this time. All levels of government should continue to strive for greater uniformity in taxation across Canada, and tax competition among provinces seeking to attract investment at the expense of neighbouring provinces should be avoided.

## Tax Structure

Because it is characterized by high nominal and marginal tax rates that are, to an extent, offset by generous incentives, the three-tier Canadian mining tax system can be capricious and sometimes unfavourable to particular sectors or segments of the mining industry. The structure is particularly unfavourable to junior mining companies that do not have mining income against which to immediately deduct the incentives and allowances that are provided. In many cases, tax deductions have to be deferred by these junior companies, making the net present worth of the incentives less than that to established producing companies. In other cases, the incentives have to be foregone completely because of carry-forward limitations.

Table 2 compares the internal rates-of-return, before and after tax, for a junior mining company versus an established producing company, for two hypothetical metal mines under 1971 and 1980 tax structures. The simulations are done for two provinces, Ontario and British Columbia. The 1971 rates-of-return are presented to provide some indication of the changes in tax burden over time resulting from changes in tax structure.

**Table 2. Comparison of internal rates-of-return before and after taxes on total invested capital for a junior mining company versus an established producing company for hypothetical metal mines under 1971 and 1980 tax structures***

| | | After tax | | | |
|---|---|---|---|---|---|
| | | Ontario | | British Columbia | |
| | Before tax | Junior mining | Established producing | Junior mining | Established producing |
| | | (%) | | | |
| DEF mine model | | | | | |
| 1971 structure | 9.35 | 7.73 | 8.48 | 7.50 | 7.75 |
| 1980 structure | 9.35 | 7.62 | 14.75 | 7.15 | 12.26 |
| CBA mine model | | | | | |
| 1971 structure | 23.04 | 19.35 | 19.96 | – | – |
| 1980 structure | 23.04 | 17.18 | 25.93 | 17.41 | 25.85 |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

* Calculated on basis of constant 1980 $.

DEF—marginally profitable, medium size, mine-mill operation.

CBA—profitable, large mine-mill operation.

Several points can be noted. First, it is clear that the tax changes since 1971 have reduced the after-tax profitability of a new mine investment for junior mining companies. Second, the reverse is true for established producing companies where the changes have greatly enhanced the after-tax profitability of new mine investments. Third, in all cases — and particularly under the 1980 tax structures — the after-tax profitability of a new mine investment for an established producer is higher than that for a junior mining company. In effect, companies that do not have existing taxable income to shelter are placed at a competitive disadvantage. This disadvantage has increased with the changes in tax structures since 1971, and has contributed, to an extent, to the decline of the junior mining sector.

The tax disadvantages of junior mining companies need to be addressed not only on the grounds of equity, but because junior mining companies historically have been more productive in finding new deposits than the senior resource companies (see *Junior Mining*) and because the decline of this sector could in the years ahead lead to an overall decline in Canadian ownership of the mineral industry. With a weakened junior mining sector, primary exploration and discovery has become heavily concentrated among senior resource corporations, where there is a larger proportion of foreign ownership and control. In particular, the major, foreign dominated oil corporations have become increasingly aggressive in nonpetroleum mineral exploration. Foreign governments also have a significant presence in Canadian mineral exploration and development. Assuming that those investors who are making most of the new mineral discoveries will also be the dominant participants in the subsequent development investments, it is obvious that the mining industry could be vulnerable to "de-Canadianization" if the junior mining sector, which is largely Canadian, were to continue to decline.

On the grounds of equity and economic efficiency, and to reduce the possibility of a decline in Canadian ownership and control of the mineral industry in the years ahead, consideration could be given to reducing the tax disadvantages faced by junior mining companies in Canada. Suggestions to improve the existing situation have included: a system of exploration grants, tax credits, exemption from capital gains and flow-through benefit provisions.

From a government standpoint, the major benefit of an exploration grant system is its flexibility — it can be designed and monitored to meet specific government social and economic objectives more easily than a tax incentive program. It can be tailored to differentiate between junior mining companies and established producing companies, as the Government of Ontario has done with its Mineral Exploration Program. A grant system also can be designed to stimulate exploration activities in specific geographical areas — precisely what has been proposed under the National Energy Program for oil and gas. The level of the grant will vary depending on whether exploration is carried out in a conventional area or in the frontier. From the perspective of a junior exploration company, a grant system would be preferable to tax incentives because cash flow would be immediately enhanced and exploration costs in net present value terms would be lower.

A grant program does, however, have drawbacks — administrative costs would be higher than for a tax incentive scheme, attempts to redirect exploration activity from one area to another or from one sector to another could be wasteful and inefficient, and unless there is a cap on the program the cost to the government could mushroom.

As far as tax credits are concerned, these would be beneficial only to junior mining companies with taxable income from activities other than mining. Those with no income would be unable to take advantage of tax credits, as they now are unable to take advantage of tax incentives and allowances until the day they earn income.

An incentive that would significantly assist junior mining companies would be to enhance the flow-through benefits transferable by them to primary equity investors, in order to roughly equalize the after-tax costs of exploration with those of established producing companies. These

additional benefits, by being immediately deductible by investors from any income, would effectively reduce for the junior sector the cost and difficulty of raising investment money.

The existing flow-through provisions for investors in shares of junior mining companies were not changed by the November 12, 1981 federal budget speech. However, the budget did make a very important change with respect to the treatment of the proceeds from the sale of such shares. Previously, the proceeds from such sales had to be taken wholly into income but now such proceeds are treated as capital gains. Capital gains receive more favourable tax treatment as only one half of the gains is considered to be taxable income.

# Foreign Ownership, Public Ownership and Junior Mining

## Foreign Ownership

The foreign ownership and control[1] of economic activity based on natural resources is an issue of justifiable concern to Canadians. Few countries currently permit the level of foreign control that is prevalent in these sectors of the Canadian economy at this time. Fortunately, the situation in the mineral industry is more acceptable than in the petroleum sector, with 64 per cent of the assets under Canadian control in 1978. This compares with 36 per cent in the petroleum sector (Table 1). Moreover, some of the dominant mining companies are Canadian controlled multinationals. In addition, a number of quasi-Canadian companies in the mineral industry have substantial foreign ownership but retain a fair amount of indigenous autonomy on investment, technology and marketing decisions (Table 2).

**Table 1. Canadian mineral industry foreign control ratios**

| Subsectors | Sales | Assets |
|---|---|---|
| | (%) | |
| Oil and gas* | 81.7 | 63.8 |
| Coal†‡ | 60.2 | 71.5 |
| Nonferrous metals† | 34.7 | 27.4 |
| Ferrous metals† | 26.3 | 33.3 |
| Nonmetallic minerals† | 66.1 | 58.6 |
| Total nonpetroleum sector | 36.4 | 36.1 |

* Canadian Petroleum Industry Monitoring Survey 1979.

† Statistics Canada CALURA 61-210 (Preliminary 1978).

‡ This figure is correct for 1978, i.e. prior to the takeover of Kaiser Resources by BCRIC in 1980. Sales are approximately 25% foreign controlled after the takeover.

In addition to the contrasting numbers on control, there are three other reasons for regarding foreign ownership in the minerals sector differently from that in the petroleum sector. First, security of supply is less pressing — the impact of any supply interruptions is less serious, the opportunity for cartel action is more limited, and the ability to use mineral resources as a political weapon is less pronounced. Second, since Canada has her own mineral industry multinationals, Canadians have comparable opportunities with foreigners to make the important decisions. Third, the mineral sector is not as profitable as the petroleum sector so that the potential problem of dividend outflows and diversion of investments is not as great.

Although the 1978 data show that 36 per cent of the assets of the mining sector are foreign controlled, this figure probably has been reduced somewhat in the last three years. In fact, foreign control of the mining industry, exclusive of coal and primary iron and steel mills, declined

[1] The National Energy Program (NEP) focuses on both ownership and control while the *Foreign Investment Review Act* and *Corporations and Labour Unions Returns Act* (CALURA) data refer to control. In this section, the focus is mostly on control with the obvious problem that any comparison with the targets of the NEP is not, strictly speaking, valid because different concepts are involved.

**Table 2. Dominant corporations in Canadian nonpetroleum minerals sector**

| Company | Estimated Canadian ownership | Control |
| --- | --- | --- |
| | (%) | |
| Inco | 60 | U.S. and Canadian management (voting stock very widely held) |
| Noranda | 85 | Brascade Resources owns 37% |
| Cominco | 80 | Canadian majority control via Canadian Pacific Enterprises (54%) |
| Kidd Creek Mines Ltd. | 100 | Canada Development Corp. owns 100% |
| Hudson Bay Mining & Smelting | 45 | Foreign effective control via Anglo American Group (43.8%) |
| Rio Algom | 30 | Foreign majority control held by Rio Tinto-Zinc (66.6%). Canadian Pacific Enterprises also owns 9.4% |
| Falconbridge Nickel | 60 | Foreign effective control (37%) held by Superior Oil Corp. via 58% owned subsidiary McIntyre Mines Ltd |
| Sherritt-Gordon | 55 | Foreign effective control held by Newmont (39.6%) |
| Denison Mines Ltd. | 80 | Canadian effective control held by Roman Corp. (34.1%). Dome Group also owns 10.1% |
| Teck Corp. | 70 | Canadian majority control held by Copperfields Mining Corp. (51%). Metallgesellschaft of West Germany also owns about 19% |
| Cyprus Anvil | 30 | Ultimate control by Dome Petroleum, pending completion of acquisition of Hudson's Bay Oil & Gas (HBOG) |
| Alcan | 40 | Canadian management control. Stock widely held by U.S., Canadian and overseas investors |

SOURCE: This table is largely based on Statistics Canada CALURA data (1979) with some adjustments.

**Table 3. Foreign control ratios for nonfuel mining sector (assets)***

| Year | Foreign control proportion |
| --- | --- |
| | (%) |
| 1969 | 60.2 |
| 1970 | 62.3 |
| 1971 | 62.3 |
| 1972 | 48.2 |
| 1973 | 47.4 |
| 1974 | 46.7 |
| 1975 | 46.7 |
| 1976 | 44.4 |
| 1977 | 42.1 |
| 1978 | 40.0 |

SOURCE: Statistics Canada (CALURA).

* Excludes coal and iron and steel mills, includes $U_3O_8$.

from 62 per cent in 1970 to 40 per cent in 1978 (Table 3). This substantial reduction reflects two factors:

- Major statistical reclassifications of some large corporations from foreign control to Canadian control status, e.g. Inco in 1972; and
- Increases in provincial public sector control via takeovers and capital investment activity, e.g. Saskatchewan (potash) and Québec (iron ore and asbestos).

Table 4 shows that there is considerable variation in control *within* the mineral industry. It is notable that those commodities where foreign control had been practically total are those where public ownership has been the principal method of altering the situation. The reason, apparently, is a lack of willingness by Canadian firms to take over foreign controlled firms involved in those commodities.[1]

All of the factors noted above indicate that the maintenance of existing levels of Canadian control in the mineral industry is fully consistent with the government's commitments to a strong Canadian presence in all sectors of the economy. However, a policy of maintaining existing levels of Canadian control is not a task without challenge since there are dynamic forces at play that have the capacity to increase foreign control. These include:

- Increasing domination by major resource corporations of the exploration phase of the mineral cycle, with obvious implications for increased foreign ownership as any resultant mineral discoveries are developed (Figure 1 and Table 5 a and b);
- Decline of the Canadian owned and controlled junior mining sector. This sector has been largely oriented to exploration, but it is also the source of new entrants into the senior producer category (Figure 2 a and b); and

[1] The other side of the coin is the economic philosophy of the governments of Saskatchewan and Québec and the high political visibility of some commodities such as asbestos.

**Table 4. Foreign control of the nonpetroleum mineral industry in Canada (upstream and downstream)**

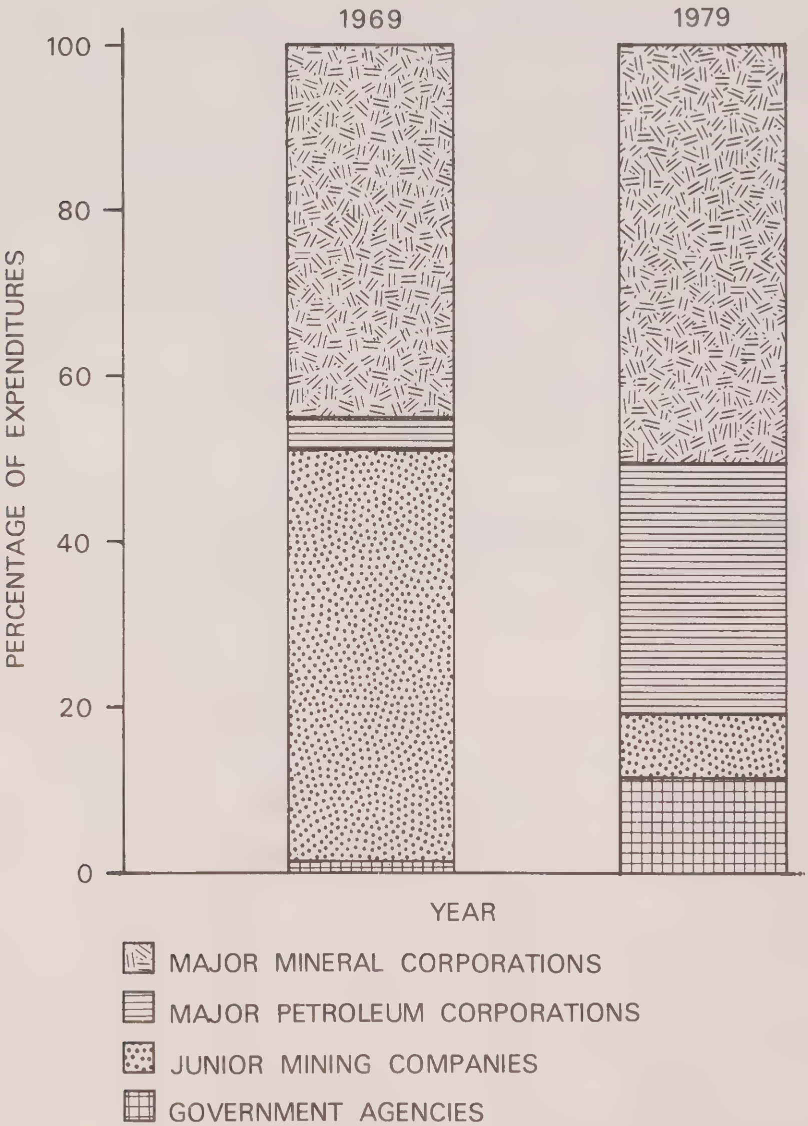
| | Sales | Assets | Equity | Profits |
|---|---|---|---|---|
| | (%) | | | |
| *Nonferrous metals* | | | | |
| Gold mines | 9.3 | 4.5 | 2.9 | 3.9 |
| Other metal mining* | 35.9 | 28.6 | 30.1 | 28.0 |
| Total | 34.7 | 27.4 | 28.1 | 25.7 |
| *Ferrous metals* | | | | |
| Iron ore mines | 93.0 | 75.8 | 82.8 | 100.0 |
| Iron and steel mills | 14.4 | 13.1 | 15.1 | 20.5 |
| Total | 26.3 | 33.3 | 39.6 | 25.5 |
| *Total metallic sector* | 30.1 | 30.2 | 32.7 | 25.7 |
| *Nonmetallic sector* | | | | |
| Nonmetal mining | 77.5 | 63.3 | 81.0 | 89.6 |
| Quarries | 18.0 | 24.6 | 26.4 | 30.8 |
| Total | 66.1 | 58.6 | 76.2 | 84.1 |
| *Other* | | | | |
| Coal mines | 60.2 | 71.5 | 73.3 | 76.6 |
| *Total* | 36.4 | 36.1 | 53.1 | 38.1 |

SOURCE: Statistics Canada, CALURA (Preliminary 1978).

* Includes both upstream and downstream operations of the integrated producers (Inco, Noranda, Cominco, Falconbridge, etc.). Also includes uranium.

FIGURE 1

# MINERAL EXPLORATION EXPENDITURES BY ORGANIZATION GROUPING




SOURCE: Resource Strategy and Economic Analysis Branch, EMR

**Table 5a. Estimated mineral exploration expenditures in Canada in 1969**

| Organizations | Expenditures ($ millions)‡ | Share (%) |
|---|---|---|
| * Inco | 18.0 | |
| Noranda Group | 11.0 | |
| * Falconbridge-McIntyre | 8.0 | 25 |
| Cominco | 7.0 | |
| Placer Dev. | 5.0 | |
| * Hudson Bay M. & S. | 5.0 | |
| * Kennco | 3.0 | |
| Teck Group | 3.0 | 8 |
| * Brinex | 3.0 | |
| * Amax | 3.0 | |
| * Newmont | 2.5 | |
| * Rio Algom | 2.5 | |
| * Asarco | 2.0 | 6 |
| * Texasgulf | 2.0 | |
| * Straus Expl. | 2.0 | |
| * New Jersey Zinc | 2.0 | |
| M.J. Boylen Group | 2.0 | |
| Sullivan Group | 2.0 | 4 |
| * Patino | 1.5 | |
| Denison | 1.5 | |
| * Umex | 1.5 | |
| * Dome Group | 1.5 | |
| * Gulf Minerals | 1.5 | 4 |
| Byrne Group | 1.5 | |
| A. White Group | 1.5 | |
| Terra Nova | 1.5 | |
| * Imperial Oil | 1.0 | |
| Bethlehem Copper | 1.0 | 2 |
| Conwest Group | 1.0 | |
| Brynelsen Group | 1.0 | |
| Others† | 101.0 | 51 |
| Total | 200.0 | 100 |

SOURCE: Estimates based on analyses of available expenditure and budget data (various sources).

* Foreign controlled.

† Mainly Canadian individuals, partnerships and "junior mining" enterprises not attached to a major promoter group.

‡ 1979 $.

**Table 5b. Estimated mineral exploration expenditures in Canada in 1979**

| Organizations | Expenditures ($ millions) | Share (%) |
|---|---|---|
| * Imperial Oil | 15.0 | |
| Inco | 14.0 | |
| Cominco | 12.0 | 25 |
| Noranda Group | 11.0 | |
| * Gulf Minerals | 9.0 | |
| * Shell Canada | 8.0 | |
| * Rio Algom | 7.5 | |
| Eldorado (Fed. Gov't) | 7.0 | 15 |
| SOQUEM (Québec Gov't) | 7.0 | |
| Sask. Mining Dev. Corp. (Sask. Gov't) | 7.0 | |
| Placer Dev. | 6.0 | |
| * Hudson Bay M. & S. | 5.5 | |
| * Urangesellschaft | 5.0 | 11 |
| * Pan Ocean | 5.0 | |
| * Falconbridge-McIntyre | 5.0 | |
| * Amoco | 5.0 | |
| * Asamera | 5.0 | |
| * Amax | 4.5 | 10 |
| * B.P. Minerals | 4.5 | |
| * U.S. Steel | 4.5 | |
| * Utah Mines | 4.5 | |
| Denison | 4.0 | |
| * Getty Oil | 4.0 | 9 |
| * Hudson's Bay Oil & Gas | 4.0 | |
| Dickenson Group | 4.0 | |
| * Serem Ltd. (Fr. Gov't) | 3.5 | |
| * St. Joe | 3.0 | |
| Manitoba Mineral Resources (Man. Gov't) | 3.0 | 6 |
| Dome Group | 3.0 | |
| Texasgulf | 3.0 | |
| Others† | 57.0 | 24 |
| Total | 240.0 | 100 |

SOURCE: Estimates based on analyses of available expenditure and budget data (various sources).

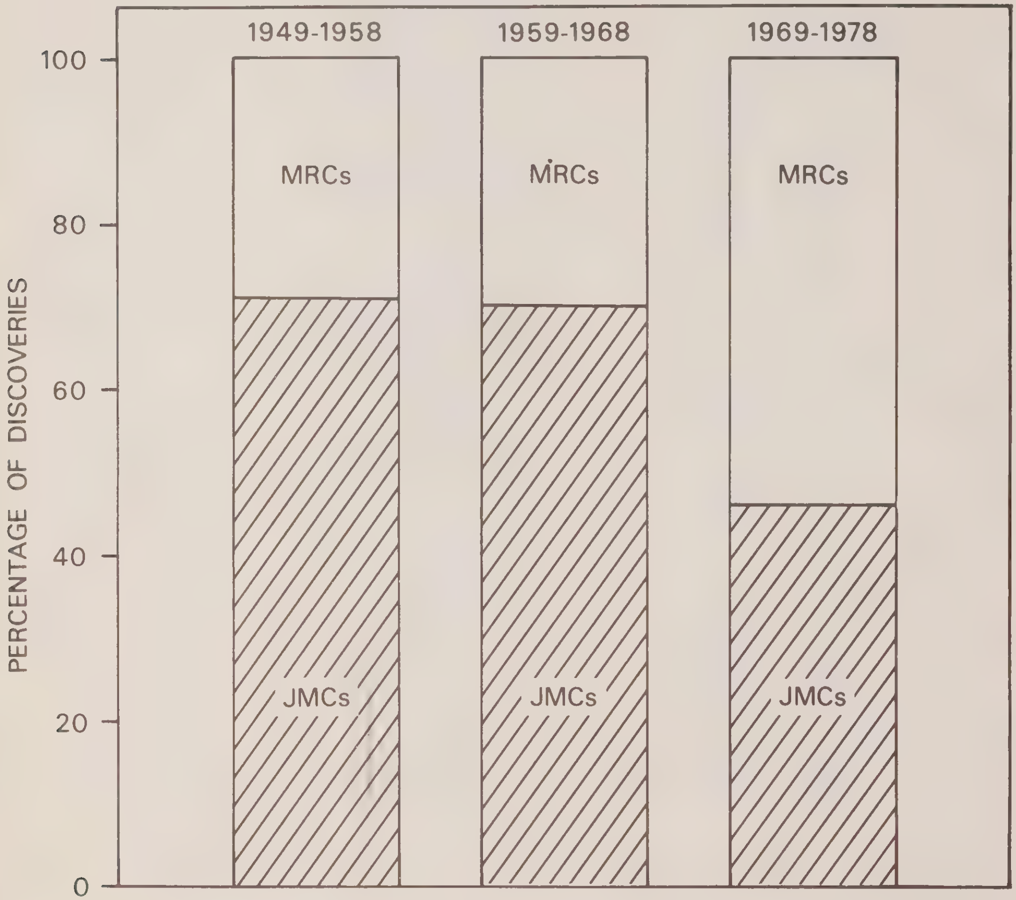
* Foreign controlled.

† About 40% "junior mining".

FIGURE 2(a)

# NON-FERROUS METAL DISCOVERIES*

## JUNIOR MINING COMPANIES (JMCs) VS MAJOR RESOURCE CORPORATIONS (MRCs)



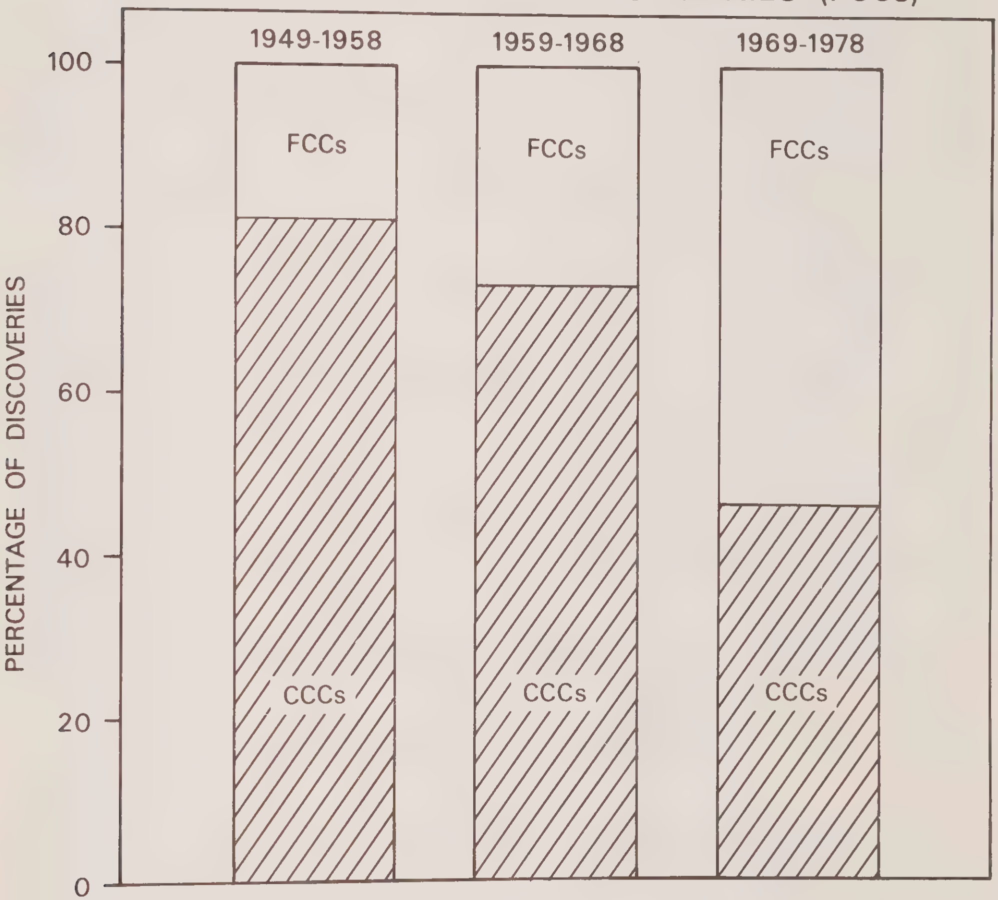

* EXCLUDING $U_3O_8$

SOURCE: Resource Strategy and Economic Analysis Branch, EMR

FIGURE 2(b)

# NON-FERROUS METAL DISCOVERIES*

## CANADIAN-CONTROLLED COMPANIES (CCCs)
## VS
## FOREIGN-CONTROLLED COMPANIES (FCCs)




* EXCLUDING $U_3O_8$

SOURCE: Resource Strategy and Economic Analysis Branch, EMR

- Increasing interest of petroleum companies, largely foreign owned and controlled, in mineral exploration, development and production (Figure 1 and Tables 5(a) and 5(b)).

These developments indicate the need for monitoring future levels of foreign ownership in the mineral sector. However, because of the current high level of Canadian ownership, no new measures to strengthen the Foreign Investment Review Agency's (FIRA) operations or policies in the mineral sector appear necessary at this time.

## Public Ownership

Public ownership in the mineral sector is not especially significant at the federal level. It includes ownership of Kidd Creek Mines Ltd. indirectly through Canada Development Corporation (CDC), part ownership of Nanisivik Mines, complete ownership of Cape Breton Development Corporation (DEVCO) and Eldorado Nuclear Limited (ENL).[1] Provincial public ownership is important in some cases such as Potash Corporation of Saskatchewan (PCS), Société Nationale de l'Amiante (SNA), Saskatchewan Mining Development Corporation (SMDC), Société Québécoise d'Exploration Minière (SOQUEM). The British Columbia Resources Investment Corporation (BCRIC) is another type of institutional vehicle for encouraging Canadian ownership and control through provincial government sponsorship.

The federal government has not had a consistent strategy on public ownership in the mineral sector but has been motivated by ad hoc considerations — DEVCO was originally established to facilitate the phase-out of the Cape Breton coal mines, ENL was founded for strategic reasons, and Nanisivik Mines on Baffin Island is intended to further social goals in a geographically remote region. The Texasgulf case was in some sense fortuitous and hardly can be considered part of a consistent policy to change the ownership of the mineral industry. Provincial governments have pursued public ownership for more ambitious reasons — control over the pattern and timing of development, exploitation of market power, achievement of social goals, and the capture of all available rents.

The crucial factor is the extent to which these objectives can be met more effectively by public ownership rather than other means. A complete framework of social accounts would be needed to come to the bottom line on this question — a task that goes beyond the scope of this paper.

The private sector has raised the issue of the favourable tax status enjoyed by publicly owned corporations — Crown corporations of one level of government are generally not taxed by the other level — as well as supposed special privileges in acquiring permits and leases. The latter is really relevant only in the case of provincially owned corporations, since federal Crown corporations are not very active in nonfuel mineral exploration and development in the Canada Lands.

A look at the role of Petro-Canada in the energy sector is helpful in determining whether the federal government should seek increased public ownership in the mineral industry. The functions of the national oil company include: (a) contributing to energy security by investing aggressively in exploration, especially on the frontier; (b) acting as an information window on the industry; and (c) pursuing state-to-state deals on oil supplies. The arguments of security and control are not pertinent for the mineral sector, as shown elsewhere in this paper. The information issue is important, but other methods can be used to achieve a satisfactory degree of disclosure. At the manufacturing stage, arguments for public ownership relate to (a) the small scale of Canadian firms, (b) weaknesses of management talent, and (c) a short-term per-

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[1] DEVCO and Eldorado involve energy minerals that are beyond the scope of this paper except for comparison or illustrative purposes.

spective concerning product and market development. Such arguments are not terribly compelling in an industry with Canadian controlled multinational corporations (MNC) such as Noranda, Alcan and Cominco. In summary, then, a mineral sector equivalent to Petro-Canada would not be required in the mineral industry at this point in time.

The remaining options on federal public ownership are:

- Reduce or eliminate public ownership, but increase government's ability to manage the sector by imposing disclosure requirements and strengthening other modes of intervention — regulation, tax/subsidy systems, etc.
- Reduce or eliminate public ownership but strengthen government's ability to influence the industry by following the Japanese model or the systems for industry-government coordination found in European countries.
- Eliminate the most obvious irritants in the industry, e.g. differences in tax treatment, and let competition determine the relative sizes of publicly and privately owned firms. In this case, few conditions aimed at social goals could be imposed on the publicly owned firms.
- Maintain the status quo, and expand or contract the publicly owned sector whenever there are specific economic or social reasons for doing so.

Each alternative has advantages and disadvantages, but the overriding point is that *at the federal level* any reduction or elimination of government ownership would have a trivial impact. Eldorado Nuclear has had only 6 per cent of uranium production in Canada although it is more important in processing. The 18 per cent share in Nanisivik is also relatively unimportant. With DEVCO, although a minor amount of Canadian coal production is involved, the corporation has a number of increasingly significant objectives such as (a) employment generation in a high-unemployment area, (b) support for the implementation of the off-oil program of the Atlantic Energy Program, and (c) improvements in coal-mining technology and safety. Government ownership of CDC is expected to decrease, but there has been little ongoing government involvement in any case. It is apparent, then, that none of the foregoing alternatives are of dramatic importance as far as the issue of public ownership at the federal level is concerned, although they may be important in defining industry-government relations.

In conclusion, it would appear that the current policy regarding public ownership of the mineral industry at the federal level should be maintained. Thus federal government ownership will be pursued only for specific public purposes where other forms of government intervention would be ineffective. No such direct government investment in the mineral industry appears justifiable at this time.

## Junior Mining

"Junior mining" refers to that sector of the mineral industry consisting of small, independent exploration enterprises. They are usually Canadian owned and controlled, and range from self-employed individual prospectors to publicly-traded corporations having annual exploration budgets amounting to a few million dollars.

In contrast to a large, integrated mining company, a junior exploration company's prospects for survival essentially reflect the probability that perhaps only one drillhole in a thousand may lead to a mineral discovery. (This is in sharp contrast to junior oil and gas companies whose drilling success rate may be as high as one out of seven in the Western Sedimentary Basin.) To be sure, the tax system reduces the riskiness of exploration activity, but to a lesser extent for junior mines since they do not have production income against which to claim deductions as expenditures are incurred.

### *Role of the Junior Mines*

Figure 1, on exploration expenditures, indicates that junior mining has gone into relative decline compared to the rest of the mineral sector. Reasons given for this decline include changes in (a) taxation, (b) securities legislation, (c) environmental regulations (development stage), and (d) relative attractiveness of other areas of risk investment such as oil and gas exploration and high-technology ventures.

Figure 2(a), however, shows that the discovery performance record of junior mining companies has not declined at the same rate as their exploration expenditures. This result is correct even when qualitative differences are taken into account by distinguishing between major and significant discoveries. Historically, there is no doubt that junior mining companies have been responsible for discovering some of Canada's major mining regions (Table 6). In fact, although the junior mining sector's share of total mineral exploration expenditures fell from approximately 50 per cent in 1969 to 10 per cent in 1979[1], this segment of the industry was responsible for 40 per cent of all new discoveries and about one third of the *major* mineral discoveries in the 1970s (Figures 1 and 2, and Table 7).

[1] Both 1969 and 1979 were years of high exploration activity.

**Table 6. Mineral discovery process—some junior mining contributions**

| Mining areas discovered | Discovery year | Major projects | Discovery year |
|---|---|---|---|
| Matagami (Québec) | 1958 | Lornex | 1965 |
| Highland Valley (British Columbia) | 1955 | Brenda | 1966 |
| Vangorda (Yukon) | 1965 | Afton | 1966 |
| Bathurst (New Brunswick) | 1952 | Brunswick M&S | 1952 |
| Elliot Lake (Ontario) | 1953 | Denison | 1953 |
| Manitouwadge (Ontario) | 1953 | Algom-Quirke | 1953 |
| Chibougamau (Québec) | 1952 | Bethlehem Copper | 1955 |
| | | Brunswick Tin | 1959 |
| | | Faro | 1965 |
| | | Geco | 1953 |
| | | Gibraltar | 1963 |
| | | Endako | 1962 |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

**Table 7. Nonferrous metal discoveries*—junior mining companies versus major resource companies**

| | "Significant" discoveries made by | | "Major" discoveries made by | | All discoveries made by | |
|---|---|---|---|---|---|---|
| | JMC | MRC | JMC | MRC | JMC | MRC |
| | | | (%) | | | |
| 1949-1958 | 82 | 18 | 52 | 48 | 71 | 29 |
| 1959-1968 | 85 | 15 | 48 | 52 | 68 | 32 |
| 1969-1978 | 65 | 35 | 32 | 68 | 46 | 54 |

SOURCE: Analysis of Energy, Mines and Resources Canada Discovery Data Base.

* Excluding $U_3O_8$.

JMC—junior mining companies.

MRC—major resource companies.

Even if the demonstrated exploration efficiency of junior mines was not equivalent to that of large corporations, there would still be reasons for concern. Continuing relative decline could bring the following undesirable side effects:

- A reduction in the number and variety of geological hypotheses that are tested in the exploration effort;
- A reduction in the rate of new entrants into the ranks of the senior producers. For example, the Denison Mines and Teck Corporation cases probably would not occur in the future; and
- A reduction in Canadian ownership and control. The junior mines are largely Canadian owned and controlled.

Even some of the large mining companies consider the revitalization of the junior mining sector as a very desirable objective. The challenge is to achieve this aim without excessive subsidization and without reverting to a taxation and regulatory regime that promotes the undesirable practices of the past — questionable share promotion activities, highgrading, unsafe working conditions, and environmental damage.

The solution to the junior mining problem involves action in four policy areas at the federal level: (a) taxation, (b) dissemination of geological information, (c) economies of scale — custom milling, and (d) R&D — exploration technology. The first is discussed in *Taxation and Incentives* and the fourth in *Mineral Science and Technology*; the other two are considered here in turn.

*Dissemination of Geological Information.* There is no doubt that more effective dissemination of geological information obtained by all companies during their exploration efforts will lead to a more dynamic and viable junior mining sector. In Alberta, junior petroleum companies have benefited greatly from the ability to re-examine and re-interpret information — drill logs, cores, etc. — filed by the majors as required by provincial regulations that are considered a model in the oil and gas industry.

Regarding mineral exploration on Crown Lands, both federal and provincial governments allow the private mining sector access to mineral rights through claim staking and the issuance of exploratory licences and permits. In turn, the industry is required to submit certain results of its exploration work with the provincial governments, the Department of Indian and Northern Affairs (DINA) and EMR. However, such submissions are usually minimal in relation to the total amount of geological, geophysical and geochemical information that is gathered.

Also at issue is the timing of release to the public of any information filed with governments. At present, assessment work filings on exploratory drilling are normally held in confidence from one to three years or longer before being made public. However, in some jurisdictions — e.g. the Yukon Territory and Ontario — there is no specified period; information may be held in confidence indefinitely, or at least until the mineral rights have reverted to the Crown.

There is general agreement within industry and government that a need exists (a) to improve the quality and substantially increase the quantity of geoscientific information and technical data filed with governments, and (b) to standardize filing requirements and confidentiality periods among federal and provincial jurisdictions. The exploration industry would benefit because wasteful duplication of geological mapping, geophysical and geochemical surveys, drilling and other expensive work would be avoided. The junior mining sector, in particular, would be able to compete more effectively with the majors if the information gap were substantially closed. Government departments responsible for resource management policies would benefit enormously from the availability of additional information in determining the total mineral resource base and in assessing the national inventories of specific minerals.

In 1978 a proposal at the Annual Conference of the Provincial Ministers of Mines strongly recommended "*that it be mandatory for the Canadian minerals exploration industry to file complete data covering all minerals exploration programs throughout Canada. The data would be retained in governmental repositories to ultimately be released to the public.*" A 1979 Report of the Subcommittee of Provincial Geologists submitted to the Provincial Ministers of Mines Conference included the following objectives and priorities for approval:

- Encourage disclosure of mineral exploration data through appropriate legislation;
- Promote improvement in provincial storage and retrieval capability of exploration and mineral deposit data; and
- Identify measures to improve the government geoscience data base in support of mineral exploration.

Complete data covering mineral exploration would probably include:

- All results of geophysical and geochemical surveys;
- All geological mapping information;
- All available information on drilling programs, including detailed logs of all drillholes; detailed assay results; maps and sections accurately showing location, azimuth, elevation inclination and depth of all drillholes; core storage, including split cores of assayed sections;
- All information on significant mineral deposits; and
- All metallurgical test work data on significant mineral deposits in Canada.

The Department of Indian and Northern Affairs is already standardizing filing requirements and reporting procedures for mineral exploration on Canada Lands. A three-year confidentiality period, followed by an automatic release of information, also will be established. A logical next step would be legislation requiring that all geoscientific and technical data gathered from any mineral exploration, development or production activity on Canada Lands be expeditiously transferred to the federal government. The question of when and under what conditions such all-inclusive information should be released to the public probably needs more study; the three-year confidentiality period followed by automatic public disclosure may not be appropriate.

Efforts by the federal government to improve the existing system of collecting, managing and disseminating the information obtained by private companies in their exploration efforts should begin in those areas under its jurisdiction, namely on Canada Lands. Once this system is put in place, provinces would be encouraged to adopt a similar approach.

*Custom Milling.* In a particular mining region, a number of high-grade, but low-tonnage, deposits may be identified but remain unexploited because the indicated reserves in each are too low to justify establishment of a mill. A potential solution is either a portable mill that could be moved from one deposit to the next as reserves are exhausted, or a centrally located custom mill to serve all deposits. The individual deposit owner would not need to obtain financing for a mill as well as a mine. In addition, a custom mill could process bulk samples, permitting a more reliable assessment of a mineral occurrence — especially significant in the case of gold deposits. The processing of bulk samples would also provide an early cash flow, facilitating further exploration and mine development.

In general, the economics of central or custom milling are potentially attractive, and there are examples — Pamour Porcupine — to prove its viability. But there are factors that inhibit privately owned and operated custom mills. Deposit owners are faced with a monopoly situation, which makes it difficult to judge whether charges are equitable. There are also risks for the operator of a central mill because most of the deposits have not been completely delineated, and the milling characteristics of the ore fully determined. However, there is considerable evi-

dence that, with some government involvement, the central milling idea could be carried further and contribute to the revitalization of the junior mining sector.

The Ontario government recently decided to implement a program ultimately costing up to $10 million and initially involving perhaps four different custom mills or expansions to existing mills. The scheme places maximum reliance on the private sector, so it is not clear how such issues as monopoly rate setting, or favourable treatment of the custom mill's own ore will be resolved. (Existing custom mills generally have their own ores to treat as well as processing those of others.) The Québec government through SOQUEM is part owner of a custom mill — Louvem — and the Nova Scotia government has proposed its own scheme. In any case, some of the technical issues and the problem of funding, especially in Canada's disadvantaged regions, indicate the desirability of federal initiatives as well.

To summarize, a custom or central mill program could aid junior mining exploration and development companies, and benefit communities in areas with numerous known, but undeveloped, gold or other mineral occurrences. Such a program could probably be implemented on a full cost-recovery basis, and be effective without being large or expensive.

A program to support custom milling thus appears to have great merit. Such a program could involve loans, loan guarantees and/or equity participation by the government but no outright grants because of the basic economic viability of the scheme. A number of steps would have to be taken before seeking approval for such a program, such as delineating the appropriate regions for such a scheme and specifying the nature of government participation.

# Infrastructure

## Introduction

Mineral developments in Canada are frequently located some distance from communities and transportation and power systems. In older mining areas most of the infrastructure needed for new developments already exists, but in new mining areas, especially remote ones, government is usually asked to provide or contribute towards the required infrastructure. In such cases, government decisions are very critical since they often determine whether or not a major project will go ahead. Thus, government can exert a major influence on the speed and direction of economic development in undeveloped regions.

Mining areas developed in the past, that required substantial infrastructure investments, include the Québec-Labrador iron ore region; the Chibougamau-Matagami region of Québec, containing copper, zinc and gold; the Lynn Lake - Thompson area in Manitoba, with its nickel, copper and zinc deposits; the Great Slave Lake area in the Northwest Territories, rich in lead and zinc; and the area surrounding Faro in the Yukon, with lead and zinc deposits. In some cases, infrastructure costs were borne mainly by the private sector, in others mainly by the public sector. For example, the 570 kilometre North Shore and Labrador Railway that serves the Québec-Labrador iron ore region, costing $127 million, was financed entirely by the private sector while the 690 kilometre, $75 million Great Slave Lake Railway, connecting Pine Point in the Northwest Territories to the Canadian National Railway, was financed by the federal government.

New mining areas awaiting development include the MacMillan Pass area of the Yukon, rich in silver, lead, zinc and barite; the northeastern region of British Columbia, containing extensive coal deposits; the Detour Lake region of northeastern Ontario, which has at least one known gold deposit; and Baffin Island, Little Cornwallis Island and Melville Peninsula in the High Arctic, containing lead-zinc and iron ore deposits. Development of these remote areas hinges on the provision of infrastructure. Suitable road access is needed for the MacMillan Pass and Detour Lake areas. The British Columbia coal region needs a 115 kilometre spur line through difficult terrain, plus rolling stock, rail-line upgrading to Prince Rupert, construction of port facilities and establishment of a new townsite. In the High Arctic, development depends on ice-breaker services and townsite facilities.

In many cases, infrastructure accounts for a significant portion of the total capital cost of a new mining project. Table 1 compares the cost of infrastructure and production assets for the Pine Point and Cyprus Anvil projects, the first in the Northwest Territories and the second in the Yukon, and outlines the share of total costs borne by the government. The Pine Point infrastructure costs amounted to 77.9 per cent of the total cost of the project. Furthermore, all infrastructure capital costs were borne by the public sector — federal funds built the Great Slave Lake Railway, provided hydro power to the mine site, built a network of roads and developed the townsite. In the case of Cyprus Anvil in the Yukon, infrastructure represented about 42 per cent of the project costs, with about 55 per cent of the infrastructure capital costs absorbed by the federal government for road construction and upgrading, provision of electric power service and development of the townsite.

**Table 1. Initial capital costs of the Pine Point and Cyprus Anvil projects**

| | Pine Point | Cyprus Anvil |
|---|---|---|
| | ($ millions) | |
| *Infrastructure* | | |
| Private sector | 0.0 | 22.0 |
| Public sector | 88.1 | 27.0 |
| *Production assets* | | |
| Private sector | 25.0 | 68.5 |
| Public sector | 0.0 | 0.0 |
| *Total investment* | 113.1 | 117.5 |
| | (%) | |
| Infrastructure as percentage of total | 77.9 | 41.7 |
| Public investment as percentage of total | 77.9 | 23.0 |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

Three points, however, should be noted in connection with these examples. First, government input was not provided free-of-charge to the private sponsors — where feasible the infrastructure was provided on a cost-recovery basis. Second, the companies involved were by no means the sole beneficiaries of the infrastructure provided. Third, the figures in Table 1 denote merely the initial capital expenditures — the companies incurred additional capital costs over the years to modernize and expand their facilities. Nevertheless, the two cases clearly demonstrate the importance of infrastructure in remote mineral development and the significant role played by government.

By accepting the high capital costs of infrastructure and spreading the recovery of costs over long periods of time, the government can ease the financial burden on private developers and increase their incentive to invest in developments. Table 2 compares rates-of-return before tax on *total invested capital* — private plus public — with *private invested capital only*, for the Pine Point and Cyprus Anvil projects. For both, the private rate-of-return diverges from the total rate-of-return because of the substantial public investment. This divergence measures the economic incentive provided by publicly funded infrastructure — the greater the divergence, the greater the economic incentive.

Two sets of estimates are given in Table 2. The first set shows the actual rates-of-return recorded between the start of the projects and 1978. The second provides a rough measure of

**Table 2. Before-tax, real, annual internal rate-of-return on private invested capital and on total invested capital**

| | Private invested capital | Total (private plus public) invested capital |
|---|---|---|
| | (%) | |
| *Historical* | | |
| Pine Point | 91 | 18 |
| Cyprus Anvil | 8 | 2.6 |
| *Expected lifetime* | | |
| Pine Point | 91 | 19 |
| Cyprus Anvil | 15 | 11.5 |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

the expected lifetime rates-of-return. The estimated rates are "real" in the sense that all cash flows were deflated, and thereby converted to constant dollars. The figures show that public provision of infrastructure greatly enhanced the profitability on private investment, particularly for Pine Point Mines Limited. In essence, the provision of infrastructure by the government raised the company's before-tax rate-of-return from 19 to 91 per cent. In contrast, the infrastructure provided for the Cyprus Anvil project raised the company's expected lifetime rate-of-return only from 11.5 to 15 per cent.

As the results in Table 2 indicate, the Pine Point project was an extremely attractive investment for the private sector, while the Cyprus Anvil project was much more modest. It should be noted, however, that the Pine Point experience is rather unique because of the unusually high quality of mineral deposits that were discovered — Cyprus Anvil exemplifies the more usual experience in base-metal mining.

Also, as indicated earlier, most of the infrastructure for both projects was provided on a cost-recovery basis, with user fees sufficient to cover operating costs, recover capital costs and provide a small return to government. Furthermore, the projects can be deemed socially desirable since the social rate-of-return for both exceeds the 10 per cent social discount rate criterion of the federal Treasury Board.

Despite this, however, the fact that both projects were attractive investments for private industry — and even may have been commercially attractive with a lower infusion of public funds — raises a few questions. Were the incentives provided by government in the form of infrastructure too lucrative? Since the government bore much of the downside risk, should it have insisted on sharing at least partially in the potential upside profits beyond a normal target rate-of-return? Should infrastructure support have been made conditional upon receiving firm guarantees from the companies regarding social objectives like industrial spinoffs, native employment, etc.?

## Issues

Any decision to provide infrastructure at public expense for remote developments should consider the following: Can and will the service be provided efficiently by the private sector? Will the total social and economic benefits of the service outweigh the total social and economic costs? If government decides to subsidize the service, will the social benefits created over and above those accruing to the private investors exceed the cost of subsidization?

Only if institutional constraints or other obstacles prevent the private sector from providing a service, or if there are overriding national objectives, should government consider providing a given service to promote public welfare. It then must be shown that the total social and economic benefits exceed the total social and economic costs sufficiently to earn the project a rate-of-return that equals or exceeds the social discount rate. Where subsidization is being considered, the social benefits of the activity must exceed the cost of the subsidization. In practice, since the realization of social benefits is so crucial to the justification of the subsidization of infrastructure, government should receive firm commitments from industry that these benefits will, in fact, be forthcoming when the deposit is developed.

In the case of unsubsidized publicly provided infrastructure — where user fees or rates are set to fully recover capital costs and operating costs, and yield a normal rate-of-return — the creation of desirable social benefits over and above those accruing to the private investors is much less relevant. The activity by itself is socially desirable as long as there are no net indirect social costs. As such, government investment in the activity need not be predicated on the creation of additional social benefits.

There are many reasons why government may want to invest in infrastructure other than to subsidize mineral developments. In some cases, the market system cannot allocate the appropriate amount of resources to the production of a service. A classic example of this is the construction and maintenance of roads and highways. In other cases, a service can be provided more cheaply and efficiently by government, which is one reason why electric power generation and distribution is largely in the hands of public utilities. On occasion, services provided under monopoly conditions can be regulated more effectively by outright public ownership than by regulatory action. In certain circumstances, when private capital is unwilling to assume risk because returns may be questionable or long delayed, government may have to provide the service to promote public welfare.

A rationale that is often cited for providing infrastructure to support mineral developments in remote areas is that of "opening up regions". Implicit in this argument is the belief that, as a natural consequence of improved access and mineral development activity, the region's population will obtain greater employment and other opportunities. This is often coupled with the argument that Canada will also benefit from additional export earnings.

In fact, public investment should not be undertaken simply for the sake of opening up a region, earning foreign exchange or creating jobs in sparsely populated areas. Job creation per se is not a sufficient justification for subsidization, nor is the generation of foreign exchange earnings. Since all economic activity creates jobs and many activities earn foreign exchange either directly or indirectly, the guiding principle in choosing among public investments must be the promotion of highly productive activities that augment national per capita income. As a general principle, mineral developments should take place only if they can pay their way.

It is often suggested that where government has invested heavily in infrastructure, it should share in future upside profits either through minority equity participation, through some form of contractual agreement with private industry for a share of profits over and above a certain minimum level, or perhaps through majority equity participation. In many cases, government indeed bears a significant portion of the downside risks for mineral developments. However, it is important to remember that governments have a greater ability to absorb risks than private firms because of the larger financial resources available to them and because of their more diversified spectrum of investments. Second, governments can minimize the risk of infrastructure investments by requiring full disclosure of all information needed to form as exact an assessment of the venture's potential as possible. This can be coupled with extensive in-house knowledge of the entire area's mineral potential, so that infrastructure can be provided and costs recovered on a regional basis. Third, governments already have levers that can be used to extract revenues from projects that turn out to be extremely profitable. Therefore, there may be no need to resort to equity participation or contractual agreements to tap excess profits. User fees for government-provided infrastructure could be increased to reflect higher profitability of the venture, and the tax system could be designed to be more profit-sensitive.

To summarize, if government is to be involved in the provision of infrastructure for entirely new mining areas or for remote mineral projects, it should do so in ways that minimize risk on its capital, and provide opportunities for sharing in profits indirectly resulting from its infrastructure investment, through user-pay charges and/or progressive taxes. Government should seek to minimize risk by ensuring multiple use of infrastructure, and by insisting on provision of sufficient data from the private sector to satisfy itself that the venture will be successful. Multiple use of infrastructure implies provision of infrastructure within a regional, rather than a single-mine, context. Repayment for infrastructure therefore may be designed on a regional basis, rather than being borne entirely by the initial mine. Of course, the distribution of costs should recognize the value to the initial user of early availability.

# Northern and Regional Development

## Introduction

Since Canada's vast northern regions are believed to harbour substantial undiscovered mineral deposits, and since mineral exploration in the more accessible southern regions has by no means been exhaustive, the federal government must continue to encourage regional mineral development. However, regional development strategies must be consistent with policies geared to fostering a viable overall national economy. Attempts to reduce regional income disparities by encouraging mineral developments that are not economically sound should be avoided, since these could be detrimental to the average Canadian and, in the longer term, even to those citizens they were originally designed to help.

## Northern Development on Canada Lands

In the northern territories, the offshore regions and in national parks, the federal government has a clear responsibility to manage the mineral base. In the case of the territories, practically all the land — more than 99.5 per cent — is under federal control. The general philosophy regarding mineral development on these lands is that market forces should determine the pace of exploration and the viability of development. However, mining is only one possible use of the land — decisions on land use must take account of alternatives as well as the interests of all affected "communities", from local to national. Furthermore, at the present time any decision-making is subject to much uncertainty because of the ongoing negotiation of native land-claims settlements.

Minerals play a highly significant role in the northern economy. Between 1972 and 1977, for the Yukon and the Northwest Territories, mining accounted for 34 and 33 per cent respectively of the total value of goods and services produced, 17 and 19 per cent of employment, and 22 and 16 per cent of value of payroll (Table 1). GDP at factor cost for mining, oil and gas in 1977 was equivalent to 55 per cent of combined net territorial income at factor cost ($223.7 million against $405.7 million). The minerals produced in the territories have also accounted for a large share of total Canadian production (Figure 1).

However, there will continue to be considerable disagreement regarding mining's environmental impact and its benefit to the native population. The subject of mining is thus a

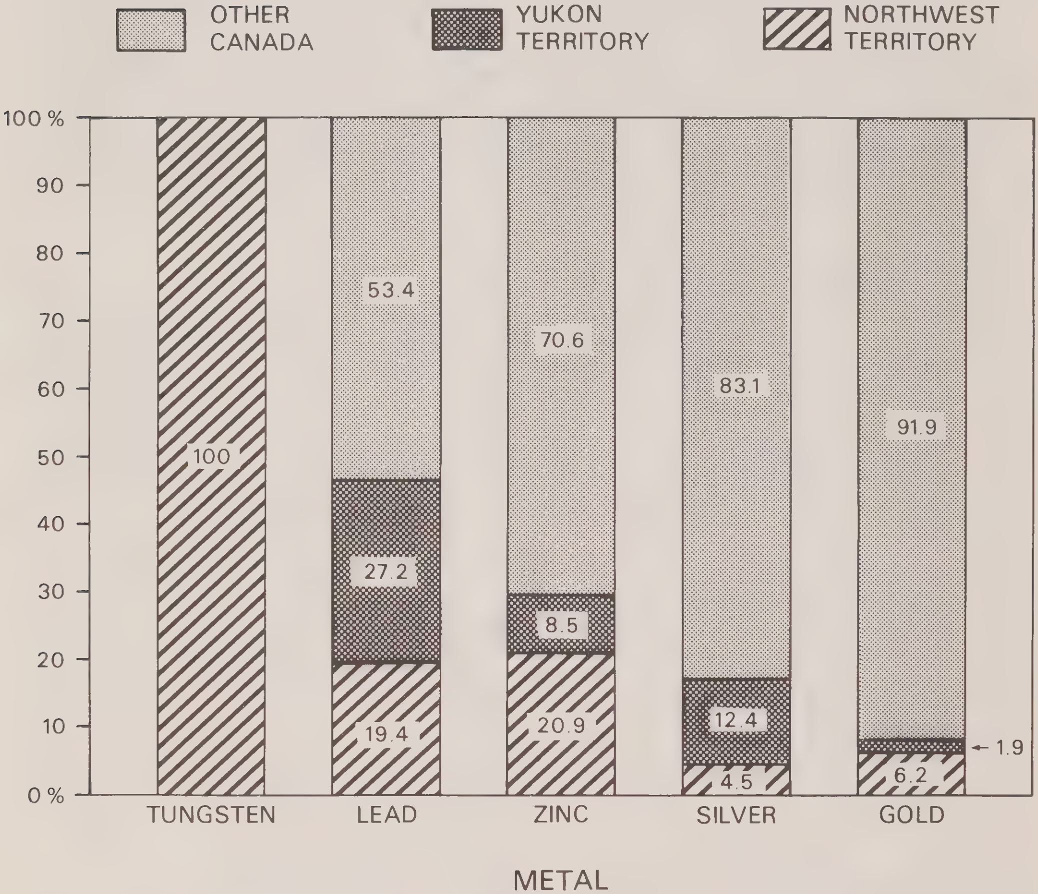
**Table 1. Structure of the economy and industrial distribution of economic activity (1972-77)**

| | Northwest Territories | | | Yukon | | |
|---|---|---|---|---|---|---|
| | Production | Employed | Payroll | Production | Employed | Payroll |
| | (%) | | | | | |
| Mining | 33 | 19 | 16 | 34 | 17 | 22 |
| Services | 17 | 22 | 21 | 27 | 36 | 27 |
| Government | 43 | 46 | 56 | 32 | 35 | 41 |
| Other industries | 7 | 13 | 7 | 7 | 12 | 10 |

SOURCE: Department of Indian and Northern Affairs.

FIGURE 1

TERRITORIAL SHARE OF TOTAL CANADIAN PRODUCTION OF SELECTED METALS 1980



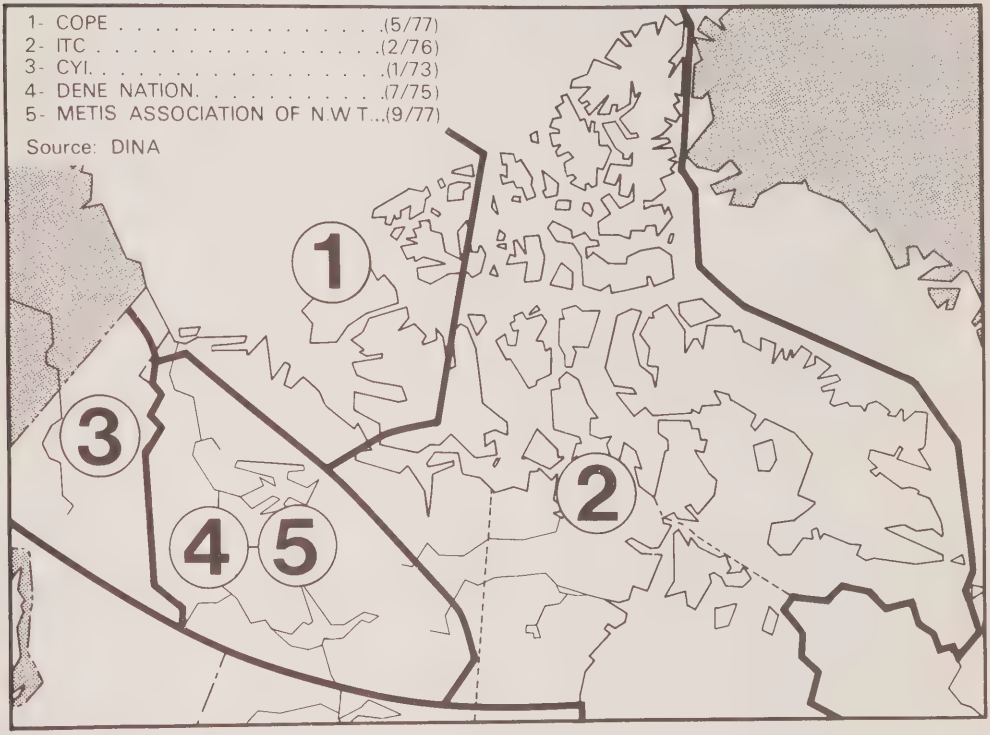

significant element in native land claims and in other land-use issues, and the industry will be strongly affected by the way these issues are resolved.

A common element in native proposals for land-claims settlement is a desire to obtain greater control over the use of land within circumscribed regions (Figure 2). This goal includes increased authority over industrial development — over decisions to proceed and over the terms, conditions and pace of development. This issue is of great importance to the mining sector, but little can be said now other than that the decision-making process for northern development is almost certain to change to some extent. It could be that the governmental structure and functions that emerge will have a greater impact on the mining industry than compensation

FIGURE 2

AREAS CLAIMED BY NATIVE ASSOCIATIONS

(WITH DATE CLAIMS INITIATED)




requirements such as land-use privileges or resource-revenue sharing. As a result, it is evident that a full enunciation of policies for the North on mineral development is intimately related to the resolution of native claims and the evolution of territorial status.

Aside from its pervasive role in the settlement of native claims, land use has had other and more immediate contentious aspects. The federal legislative base for land-use administration was designed to foster northern development with "due regard" for environmental protection. The mechanisms for managing land use were put in place primarily to monitor development proposals to ensure that unacceptable environmental damage did not occur. This system proved to be rather unsatisfactory for resolving conflicts between competing land uses. As a result, the Department of Indian and Northern Affairs recently announced a new northern land-use planning policy, which it is now implementing.

Another problem is a lack of sufficient information to assess development proposals accurately. Conducting land management with very limited natural-resource information is not a desirable state of affairs. Therefore, increased efforts of the Geological Survey of Canada will be focused on Canada Lands, and the use of resource assessment programs in evaluating land-use proposals must become more widespread. The information thus generated will not only help the government make land-use decisions, but will also aid the private sector's exploration effort.

Furthermore, it would be advisable to establish uniform standards for the full and systematic disclosure of geological information (see *Junior Mining — Dissemination of Geological Information*).

The federal government also intends to modernize the taxation system respecting Canada Lands. This matter is currently the subject of government review.

The issue of Canadian ownership has been addressed to some extent in Section 58(10) of the *Canada Mining Regulations*, though this applies only to the Northwest Territories. These regulations ensure that mineral leases will not be granted to a corporation unless it is 50 per cent Canadian owned or unless its shares are listed on a recognized Canadian stock exchange and are thus available to Canadians. There is no similar legislation for the Yukon. Also, where a foreign company initially enters into mineral development that represents business unrelated to its previous Canadian activities, FIRA approval is required. Generally, however, there have been no unusual measures taken to ensure that northern mineral development is predominantly Canadian owned. In this respect, government policy on mineral development differs from that on oil and gas development (see *Foreign Ownership, Public Ownership and Junior Mining*).

The federal government clearly must establish a regulatory climate that will reconcile economic and social concerns regarding northern mineral development. Furthermore — particularly once the issue of native land claims has been settled — if market forces are allowed to determine which deposits are proposed for development, there will be no potential disruption of the regional society without an almost certain prospect of economic compensation.

As the level of mineral development rises on Canada Lands, there will be a need for greater hydroelectric power availability, for efficient transport systems, for navigational aids and assistance, and for social services. The federal government has been and will be prepared to provide these goods and services to complement and promote mineral development, but only on the basis of realistic economic expectations and wherever possible on a cost-recovery basis (see *Infrastructure*).

Also, some services could be provided in greater anticipation of future demand. This is especially important with respect to hydroelectric power — under the provisions of its charter, the Northern Canada Power Commission can now entertain requests for immediate power requirements only, whereas it could perhaps in the future be permitted the same flexibility as that enjoyed by utilities elsewhere in Canada in building for future demand.

In summary, these initiatives — the increased provision of information, the reform of the regulatory and administrative climate and the early resolution of native land claims — will remove a great deal of uncertainty and should create an atmosphere that will encourage industrial development and effectively reconcile the diverse interests of Canada's disparate northern community.

## Regional Development on Provincial Lands

The mineral resource base "south of 60" may also offer opportunities to reduce regional economic disparities. In most of Canada's relatively disadvantaged regions, i.e. the Maritimes and Gaspé, the search for minerals has already been quite extensive. However, continuing advances in geological theory and exploration methods indicate that a renewed exploration effort might reveal previously undetected deposits. If these are found and can be developed, they would introduce a new source of economic activity into regions where the social gain would be greater than in regions with more fully employed resources. The federal government, therefore, will

continue to support the development of more advanced exploration instruments and techniques and, through federal-provincial agreements, continue to support provincial initiatives on equipment design and generation of geological information.

Where deposits are only marginally economic, incentives can be provided to attract industry, but this is only feasible where a mining company would utilize significantly underemployed resources. The cost of the incentive, e.g. subsidization of the company's capital expenses, would have to compare favourably with the expected gain. This is one approach the federal government will pursue, though with caution. This principle can also be applied to the siting of mineral or metal processing operations in particular localities.

There are clear limitations in subsidizing mineral development to reduce economic disparity. In particular, such opportunities are determined largely by geology. Also, the local mineral resource must in fact be just at the margin and the prospects of employing under-utilized human resources must be truly significant if subsidization is to be considered.

Of course, regional economic stress can result not only from depressed conditions, but also from "overheated" conditions. Regions experiencing a boom in economic activity often have difficulty in coping with the demands placed upon them for services. Also, such economic pressures can exacerbate or introduce social stresses into the community. Therefore, government has a role to play in alleviating the adverse effects of rapid development, preferably by appropriately channeling the benefits to be realized from sharply increased economic activity.

## Single-Sector Communities

In guiding any mineral development that will create a community dependency upon the sector (Figure 3), the realities of such dependency must be recognized. While the resource here is nonrenewable, many mineral projects have a very long expected lifetime of a century or more. Many others, however, will not be nearly as long-lived and will provide employment to the factors of production only for a dozen years or so. In single-sector communities it is important, under the auspices of DREE, to fully exploit all possible linkages and to develop parallel and supplementary industrial activities to maximize benefits from mineral developments. This is particularly important where mineral activities are not expected to be long-lived. Here, there is a clear need to develop a strong industrial base in order to sustain the local and regional economies and maintain employment levels over the longer term. Therefore, DREE's capability in regional planning and delivery of regionally-coordinated programs will continue to play a critical role.

Where this is not a possible option, there is the need for mobile capital, private and public, and a mobile work force. But the need to relocate can cause exceptional stresses and costs — human problems that are not always met satisfactorily by governments or by the employer. Attention should therefore be focused on the needs of the people in relatively short-lived communities. Towards this end, a mobility account funded by the employer could be considered. As a preliminary step, a study of the actual costs incurred by government as the result of a mine shut-down, given existing public programs designed to cushion some of the impact upon the community, will be conducted.

FIGURE 3

## SINGLE-SECTOR COMMUNITIES


SOURCE: Based on "DREE", Single-Sector Communities (Revised 1979)

# Employment and Quality of Working Life

## Introduction

Maximization of per capita income in Canada has been established as a basic objective of government policy in the mineral sector. But not all the costs and benefits of mining can be found in profit and loss statements or wages. There are, for example, the costs society must bear for environmental damage, industrial accidents or health impairment. Such quality-of-life issues do not show up directly on the balance sheets, but they undoubtedly affect profitability. Every year from 1969 to 1977 significantly more man-days were lost in Canada because of work-related injuries than because of strikes and lockouts.[1] Labour shortages in 1974 cost the mining industry $250 million in lost production, while recruitment and training necessitated by high employee turnover cost an additional $50 million.[2]

## General Trends in the Labour Market

At first glance, the mineral sector does not appear to face any great difficulty regarding labour supply during the 1980s. Only a modest growth in labour requirements is expected — about 1 per cent per year. With a growing labour force and a higher wage level than other industries, there would appear to be no reason for concern. However, there are two off-setting factors. First, the unsatisfactory cyclical pattern of employment that prevailed through the 1970s is expected to continue in the 1980s. During the 1970s labour bottlenecks occurred during boom periods in the mineral industry, while layoffs were common during recessionary periods.

Second, there is a rapidly growing demand — and therefore competition — in the petroleum sector for similar types of manpower. While employment in the nonfuel sector is expected to increase only 1 per cent per year, employment in the mining and petroleum sectors as a whole is expected to increase by an average of 2.9 per cent per year over the decade, with annual ranges from 2 to 6.6 per cent. Delayed scheduling of oil-sands plants may mean that several of these projects could proceed simultaneously, thereby further aggravating labour bottlenecks.

In addition to these two major factors, a number of other employment challenges could arise during the 1980s from the following trends:

- Increasing concern by workers over nonwage aspects of their employment — health and safety, location of community and access to services, job security, provision of pensions;
- A continuing shift toward occupations in the mineral sector for which there is also high demand elsewhere in the economy — a shift away from the traditional miner to the skilled tradesperson;
- Lower levels of immigration, especially in the more skilled occupations increasingly required by the mineral industry;

[1] Economic Council of Canada, *Reform of Regulation*, 1981.
[2] Mining Association of Canada.

- The shift toward two-income families and hence the possibility, as well as the need, to tap nontraditional sources of labour, e.g. women; and
- The shift to more northern and isolated orebodies and, therefore, a greater possibility of employment opportunities for natives.

## Specific Labour Issues

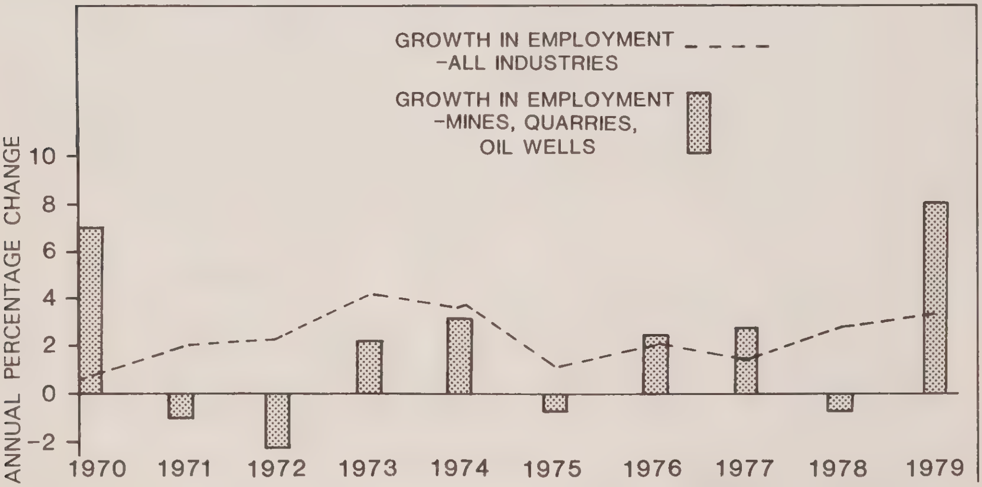
In the past, the industry offered higher wages and other financial incentives to compensate for the less attractive aspects of working in the mineral sector. However, this strategy may not be effective in future. It would be difficult to pay a wage high enough to compensate a family for the loss of a second income where the first wage-earner is involved in mining, and the spouse has no employment opportunities. Similarly, it is difficult to see how a person can be readily compensated for a fatality rate 10 times that found in manufacturing. Alternative approaches to a number of problems must be sought.

### Bottlenecks

Production bottlenecks arising from shortages of skilled labour are currently being experienced by all sectors in the Canadian economy. This problem will be exacerbated by the high level of new investment expected in the energy sector over the next five to seven years. Figure 1 shows

FIGURE 1

EMPLOYMENT GROWTH IN MINING, QUARRIES AND OIL WELLS
1970-1979



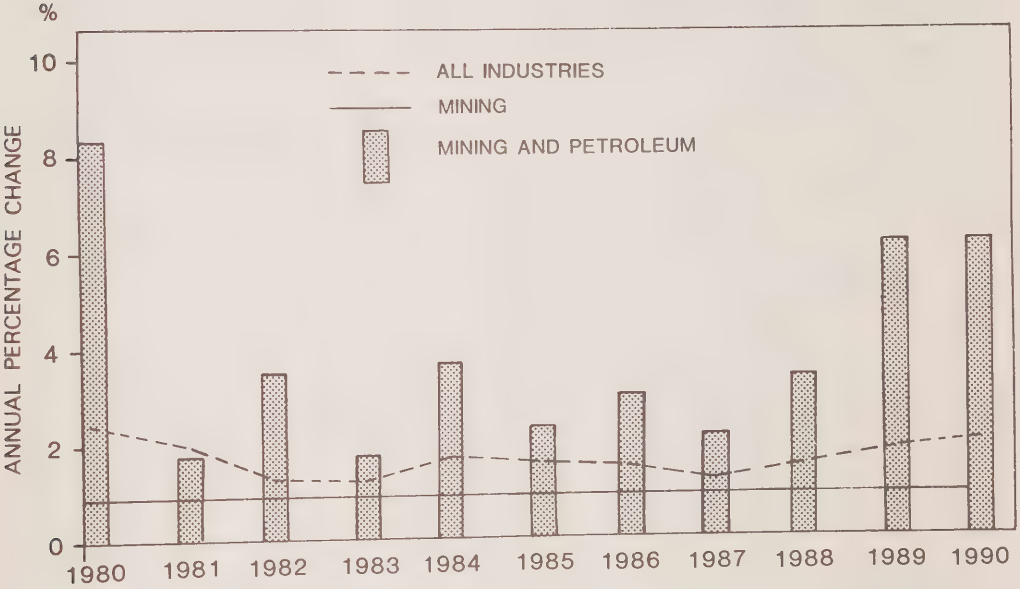

SOURCE: Statistics Canada and Informetrica

the degree of cyclicality in employment experienced by the mineral industry over the 1970s, while Figure 2 shows the trend that can be expected in the 1980s.

Bottlenecks in 1979 and 1980 resulted from expansion of the industry, the response to higher mineral prices and the end of the Inco strike. They were exacerbated by demand for labour by the energy sector, and high employee turnover. While employment contracted by 1.4 per cent in 1978, it rose by 8 per cent in 1979, and increased by 9 per cent in 1980. However, the general labour constraint is expected to have eased in 1981, with employment in the industry expected to increase by only 2 per cent (Figure 2). Thereafter, it is expected to grow by 2 to 4 per cent per year until 1989. Then, the rate will accelerate to more than 6 per cent as miners and skilled technicians are hired by the tar-sands plants.

FIGURE 2

EMPLOYMENT GROWTH IN MINING QUARRIES AND OIL WELLS 1980–1990

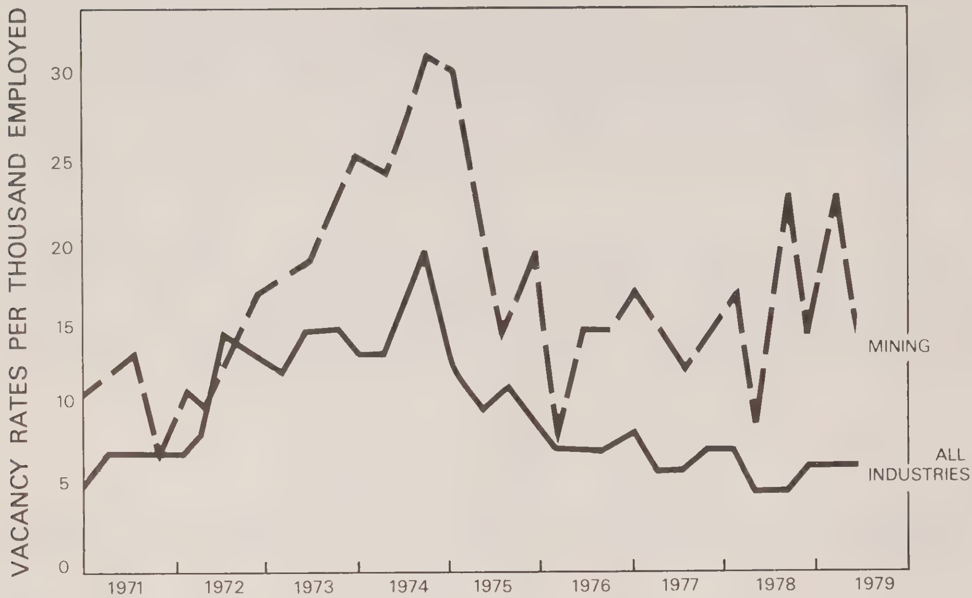



SOURCE: Statistics Canada and Informetrica

Vacancy rates in the mineral sector have traditionally exceeded the national average for all industries, despite a higher level of wages (Figure 3). During 1974 — the last period of bottlenecks prior to the current period — the mineral industry had a vacancy rate of 26 per thousand workers, compared to 16 per thousand in all other industries. Within one year, the vacancy rate in the mineral industry then dropped to one quarter the 1974 level.

FIGURE 3

# VACANCY RATES - MINING COMPARED TO ALL INDUSTRIES




SOURCE: Statistics Canada #71-203 (Quarterly Data)

Aggregate vacancy rates mask the critical nature of bottlenecks that arise from a shortage of skilled personnel. More than one fourth of the mineral industry vacancies in 1979 were trades personnel — all categories of workers for which the mining industry had to compete against other sectors. As Table 1 shows, most of the skilled vacancies were either mechanics,

**Table 1. Skilled hard-to-fill vacancies (1979)**

| Trades with highest number of vacancies | Number | Percentage of total skilled vacancies |
|---|---|---|
| | | (%) |
| Electrician | 218 | 20.0 |
| Industrial mechanic (millwright) | 209 | 19.0 |
| Heavy duty mechanic | 160 | 14.4 |
| Welder | 112 | 10.0 |
| Diesel mechanic | 82 | 7.4 |
| Other | | 29.2 |
| Total | | 100.0 |

SOURCE: Mining Association of Canada Survey.

electricians or welders. Shortages in these categories can be expected to continue, with the greatest demand occurring on the Prairies.

The shortage of skilled manpower is an economy-wide problem being dealt with through national programs sponsored by the Canada Employment and Immigration Commission (CEIC) in cooperation with several industry sectors. In an effort to match mineral-sector vacancies with available manpower, the Mining Association of Canada, in conjunction with CEIC and EMR, has established a toll-free number, "The Mine Line" (1-800-268-9702), to be used for recruitment.

The derivation of maximum benefits from CEIC programs implies greater emphasis on industry-based training, increased opportunities for apprenticeship, and possibly the establishment of new certifiable occupations. As well, it implies more active recruitment of personnel from nontraditional sources such as women and native people. Obviously, wages must remain competitive with those in other sectors such as energy or, in the case of British Columbia, forestry. Moreover, workplace health and safety programs will have to be augmented.

## Turnover

Labour bottlenecks in the mineral industry are aggravated by high levels of turnover. During the last period of significant employment expansion in the metal mining sector (1974), turnover rates averaged 128 per cent in the unskilled category, 50 per cent among skilled and 22 per cent among management and supervisory staff. A recent survey by the Mining Association of Canada estimated national turnover rates in 1979 of 12 per cent for skilled and 24 per cent for semiskilled workers, but only 16 per cent for miners (Table 2).

Clearly, the problem of turnover is less severe now than in 1974. However, attrition rates on the Prairies, in British Columbia and in the territories were approximately double the

**Table 2. Attrition rates***

| | Actual | | M.A.C. member forecast | |
|---|---|---|---|---|
| | 1979 | 1980 | 1981 | 1982 |
| | | (%) | | |
| *Semiskilled workers* | | | | |
| Atlantic Provinces | 11 | 7 | 7 | 7 |
| Québec | 13 | 8 | 8 | 8 |
| Ontario | 16 | 16 | 16 | 16 |
| Prairies | 47 | 41 | 41 | 41 |
| British Columbia | 45 | 43 | 46 | 46 |
| Territories | 38 | 34 | 35 | 34 |
| Canada | 24 | 21 | 21 | 21 |
| *Miners* | | | | |
| Atlantic Provinces | 24 | 12 | 12 | 10 |
| Québec | 19 | 16 | 17 | 13 |
| Ontario | 13 | 17 | 17 | 17 |
| Prairies | 31 | 30 | 27 | 28 |
| British Columbia | 30 | 23 | 23 | 24 |
| Territories | 31 | 42 | 43 | 41 |
| Canada | 16 | 19 | 17 | 18 |

SOURCE: Mining Association of Canada (M.A.C.)

* Attrition is defined in terms of workers leaving paid employment at a specific company for any reason.

national average — the problem appears to be more regional than national, reflecting competition for labour from related industries or, in the case of the territories, the isolation factor.

To address this problem, the mineral industry will have to increase retention rates, and thus complement national measures for improving the supply of skilled labour. Efforts to reduce worker turnover could include improved housing, social amenities, programs providing for upward mobility of workers and commuting of workers from established communities.

## Native Issues

Native concerns arise from conflicts over land claims, access to employment in the mineral sector, and conflicts between traditional pursuits and mineral development.

The location of many Indian reserves within commuting distance of mineral deposits would appear to be a happy coincidence. It should mean a supply of workers to an industry with high labour turnover and bottlenecks, and job opportunities for a segment of the population whose average unemployment rate exceeds 50 per cent. But this equating of supply and demand has not taken place — less than 1 per cent of the national labour force in the mining industry is native. Even in the Northwest Territories, where manpower shortages have been particularly acute and where native people account for about half of the labour force, only 6 per cent of the mine workers are native (Table 3).

**Table 3. Native employment in mining on Canada Lands (May, 1978)**

| Producing mine | Work force | Number of natives | Percentage of work force |
|---|---|---|---|
| | | | (%) |
| Cantung | 164 | 4 | 2.4 |
| Con-Rycon | 236 | 5 | 2.1 |
| Giant | 340 | 8 | 2.4 |
| Pine Point | 650 | 52 | 8.0 |
| Echo Bay | 120 | 0 | 0 |
| Nanisivik | 168 | 22 | 13.1 |
| Terra | 60 | 14 | 23.3 |
| Northrim | 14 | 0 | 0 |
| Anvil | 500 | 16 | 3.2 |
| United Keno | 275 | 10 | 3.6 |
| Whitehorse Copper | 209 | 13 | 6.2 |
| Total Northwest Territories | 1752 | 105 | 6.0 |
| Total Yukon | 984 | 39 | 4.0 |
| Total both territories | 2736 | 144 | 5.3 |

SOURCE: Department of Indian and Northern Affairs (DINA). Another DINA source puts native employment at Nanisivik at 20-25% over the past 4 years.

The Nanisivik mine in the Arctic, supported by the federal government primarily to create native employment, has had a level of only 13 per cent natives in the mine work force, although recent data show levels as high as 25 per cent native. In the Yukon, a 15 per cent native population provides only 4 per cent of the mine work force.

The federal government has developed a broad range of programs to support native employment. Many of the opportunities to employ native people will arise from private sector developments. Much native concern over resource development stems from fears that access to

traditional pursuits — hunting, fishing, trapping — will be severely disturbed. But objections to resource development could be reduced if native people understand that resource-based employment can be a viable alternative to traditional pursuits.

Some companies have hired an employment liaison officer to canvass native communities for workers. More comprehensive efforts are sometimes necessary. The Amok agreement with the Saskatchewan government provides for 50 per cent employment of northerners, modification of the work environment to facilitate employment of northerners, family counselling, commuting assistance, and financial and managerial support for native-run service industries. Some successful native employment programs have been demonstrated and could be more widely adopted.

Experience has shown that special efforts by both government and industry are necessary to ensure that the barriers to native employment in the mining industry are overcome. Measures to recruit, train and retain native workers have included work environment modification, quotas, company-sponsored commuting, training, and financial and managerial assistance to native service businesses. Some native organizations, such as the Inuit Development Corporation, are increasingly in a position to act as a source of supply of native workers to industry in the North. Firms are encouraged to work through such organizations in their hiring process. Close cooperation between private industry and governments in the territories and provinces will ensure the development of effective native employment programs.

## Female Employment in the Mining Sector

Despite severe shortages of skilled and semiskilled personnel in the mining sector, only selective efforts appear to have been made to recruit and train women to fill these vacancies. While the number of women employed in the mineral sector has more than doubled over the past 10 years, almost all of this expansion has occurred in traditional female occupations such as clerical, administration and bookkeeping.

Table 4 shows that while females in 1971 constituted 47 per cent of employees in clerical and related occupations in the metal-mining sector, they represented less than 0.5 per cent of the sector's largest group — the production occupations referred to as mining and quarrying. For those skills that are in particularly short supply — electricians, welders and mechanics — women constituted only 0.4 to 0.6 per cent of employment.

A more recent survey, conducted by the Mining Association of Canada, showed that some progress has been made over the past decade. While overall female employment in metal mining rose from 4.2 per cent in 1971 to 4.7 per cent in 1979, almost 32 per cent of the female positions were in areas classified as nontraditional, compared to 13 per cent in 1971. Most companies employing females in nontraditional occupations felt they performed as well as or better than males. In particular, absenteeism and turnover were lower than for males. Companies also cited savings in accommodation costs by being able to employ a couple where one member was already entitled to company housing. A majority of companies employing females indicated they intended to increase recruitment of females for nontraditional positions while one third indicated they would keep proportions the same.

However, more than one third of the companies responding to the survey employed no females in nontraditional occupations and did not expect to be in a position to do so in future. Thus, there appears to be considerable room to broaden programming aimed at recruitment and training of females.

Major constraints on female participation in nontraditional jobs appear to be limited availability of day care, limited housing for single women and limited plant facilities for women. Of companies responding to the Mining Association of Canada survey, 3 per cent sponsored daycare facilities, and 33 per cent had facilities within the community. The remaining 64 per cent

**Table 4. Occupations in Canadian metal mines (1971 census)**

| | Total* | Percentage of total | Male | Female | Percentage female |
|---|---|---|---|---|---|
| | | (%) | | | (%) |
| Managerial, administrative | 1 630 | 2.4 | 1 575 | 55 | 3.4 |
| Natural science, engineering and mathematics | 5 570 | 8.2 | 5 420 | 150 | 2.7 |
| Clerical and related | 4 340 | 6.4 | 2 290 | 2 050 | 47.2 |
| Service occupations | 1 395 | 2.1 | 1 250 | 150 | 11.0 |
| Mining and quarrying | 28 080 | 41.3 | 27 945 | 135 | 0.5 |
| Processing occupations | 3 735 | 5.5 | 3 700 | 35 | 0.9 |
| Machining | 2 495 | 3.7 | 2 485 | 10 | 0.4 |
| Product fabricating, assembling and repair | 6 655 | 9.8 | 6 635 | 25 | 0.4 |
| Construction trades | 4 385 | 6.4 | 4 355 | 25 | 0.6 |
| Transport equipment operating | 3 135 | 4.6 | 3 110 | 20 | 0.6 |
| Materials handling | 2 735 | 4.0 | 2 725 | 10 | 0.4 |
| Other crafts and equipment operators | 835 | 1.2 | 825 | 10 | 1.2 |
| Other | 800 | 1.2 | 715 | 85 | 10.6 |
| Not classified or stated | 2 270 | 3.3 | 2 205 | 65 | 2.9 |
| Total | 68 060 | 100 | 65 235 | 2 825 | 4.2 |

SOURCE: Statistics Canada, Special Bulletin 1971 Census of Canada, Economic Characteristics: Occupation by Industry, Cat. No. 94-792 (SE-1) (Ottawa: Information Canada, May 1976), Table 2.

* Male and female do not always exactly add up to the total because of census rounding to the nearest 5.

apparently lacked day-care facilities. Approximately 28 per cent of the companies provided flexible hours for working couples, presumably to help compensate for the lack of day-care facilities.

A 1976 British Columbia study into means of recruiting women into nontraditional positions in the mining sector made the following recommendations:

- For new developments, government should negotiate a development agreement that includes a plan of action to recruit women in all phases of mining.
- The position of Women in Mining Liaison Officer should be established to act as a resource person with industry in developing strategies to recruit and hire women, advise government on training needs, and monitor results.
- Both levels of government should develop special programs to involve women in preapprenticeship and apprenticeship programming.
- A full-time child care organizer should be hired to develop facilities in conjunction with company and municipal services.
- Provision of washrooms and dries for women should be compulsory.[1]

In addition, a 1976 EMR study recommended increased educational efforts on the part of industry, government and unions to attract more women into mining professions.[2]

[1] From *Women in Mining*, Susan Veit, October 1976.
[2] *Women in Mining: The Progress and Problems*, EMR, 1976.

These proposals merit detailed study by government, in conjunction with the industry, and their implementation in the territories and in mines falling under federal jurisdiction, e.g. DEVCO, should be considered.

Clearly, skilled labour shortages in the mineral industry can be alleviated by recruiting and training women. Labour code barriers to female employment in underground mining have been removed, and the federal government provides special funding to train women in nontraditional occupations. Action by the private sector is now needed to adopt recruiting and training programs such as those recommended in the British Columbia and EMR reports. Supportive programs such as day-care facilities may also have to be sponsored by the employer. This should reduce labour turnover by providing income opportunities for couples, particularly in northern and remote communities where employment opportunities for females are limited. It is worth noting that Nanisivik guarantees a job to the spouse of any employee and that full day-care facilities are provided by the company.

## Workplace Health and Safety

Workplace health and safety has become a major industrial concern, particularly as knowledge of occupational diseases grows. The direct cost of accidents and industrial disease is increasing as compensation payments are raised to reflect broader definitions of compensable diseases and wage increases. The indirect cost is estimated to exceed compensation assessments by at least a factor of three. For all industries, the total costs of accidents and occupational diseases to the economy are estimated at $4 billion for 1978.[1]

The fatality rate in the mining sector, at 1.23 per thousand, averages 10 times the rate in manufacturing (Table 5). While forestry and fishing rates appear higher, the mining sector has almost twice the number of employees of these two sectors. Although the fatality rate in mining dropped from 1974 to 1978 (Figure 4), it has begun to climb again.

The rate of nonfatal injuries in the mining sector also appears to exceed that in other industries. In Ontario, an average of 9 of every 100 workers was injured each year in the first half of the decade (Table 6). In the latter half of the decade, this figure had risen to more than 17 per 100 workers annually.[2] The severity of injuries is also higher, with 37 to 49 days off per injury in the two provinces for which data are readily available.[3] Compensation payments for these injury rates had risen to a level of $23.5 million in Ontario by 1976, for a work force of approximately 41 000.[4] This amounts to more than half the total royalties earned by the province from mining in the 1976-77 fiscal year.

Some sectors of the mining industry have incurred fairly high costs to improve health and safety. In uranium mining it was necessary to double operating costs to reduce death and disease rates to acceptable levels. However, substantial reductions in accident and fatality rates can be made elsewhere at considerably less cost. Also, the mining industry must take into account the savings that can result from improved health and safety — reduced absenteeism, lower turnover and higher productivity.

Accident rates vary by type of mine and by occupation within mines. Open-pit mines are safer than underground mines, with the fatality rate in the former only about one third that for the latter (Table 7). The fatality rate in underground silver mines is nine times that in underground nickel mines. Mills and smelters provide the safest working environment, followed by

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[1] Economic Council of Canada, *Reform of Regulation.*
[2] S. Nousianen, *Occupational Health and Safety in Canadian Mining: The Federal Jurisdiction*, Sept. 1980, p. 4. Note that this figure may be inconsistent with the source in Table 6.
[3] S. Nousianen, *Occupational Health and Safety in Canadian Mining: The Federal Jurisdiction*, Sept. 1980, p. 5.
[4] Mines Accident Prevention Association of Ontario, Annual Report, 1977.

**Table 5. Fatality* rate† by industry in Canada**

| Year | Agriculture | Forestry | Fishing | Mining | Manufacturing | Construction | Transportation | Trade | Finance | Community service | Public administration | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 24.4 | 133.9 | 236.8 | 142.1 | 12.3 | 62.1 | 31.2 | 5.7 | 0.7 | 2.8 | 15.1 | 17.1 |
| 1970 | 12.1 | 147.8 | 357.1 | 121.5 | 11.1 | 53.6 | 28.0 | 5.7 | 1.3 | 3.2 | 18.1 | 15.8 |
| 1971 | 16.3 | 156.1 | 137.5 | 134.3 | 11.5 | 57.6 | 29.9 | 7.1 | 1.3 | 3.9 | 14.1 | 16.6 |
| 1972 | 24.2 | 136.3 | 98.8 | 141.3 | 15.5 | 51.7 | 32.5 | 6.2 | 1.8 | 5.6 | 13.0 | 17.4 |
| 1973 | 24.8 | 157.5 | 164.8 | 143.4 | 14.6 | 53.1 | 37.4 | 6.9 | 1.6 | 4.8 | 19.4 | 18.4 |
| 1974 | 27.0 | 131.2 | 137.5 | 152.3 | 16.8 | 52.1 | 33.2 | 8.8 | 1.7 | 4.7 | 11.3 | 18.0 |
| 1975 | 9.5 | 124.6 | 325.3 | 120.2 | 12.6 | 48.4 | 28.3 | 5.4 | 0.7 | 3.6 | 14.3 | 14.6 |
| 1976 | 12.7 | 114.3 | 360.0 | 117.9 | 11.0 | 41.6 | 27.9 | 4.4 | 2.3 | 2.6 | 8.9 | 13.0 |
| 1977 | 11.2 | 91.6 | 236.8 | 90.3 | 10.1 | 36.6 | 22.1 | 5.2 | 1.9 | 2.6 | 7.9 | 11.3 |
| 1978p | 4.5 | 106.6 | 134.6 | 71.6 | 7.9 | 30.5 | 21.4 | 3.5 | 0.8 | 1.6 | 9.5 | 9.3 |
| 1969-78 average | 16.2 | 129.4 | 207.3 | 122.7 | 12.4 | 40.3 | 29.0 | 5.8 | 1.6 | 3.5 | 12.8 | 15.0 |

SOURCE: Fatalities in Canadian Industry 1969-78 Program Research and Development Occupational Health and Safety Branch Labour Canada, Nov. 1979.

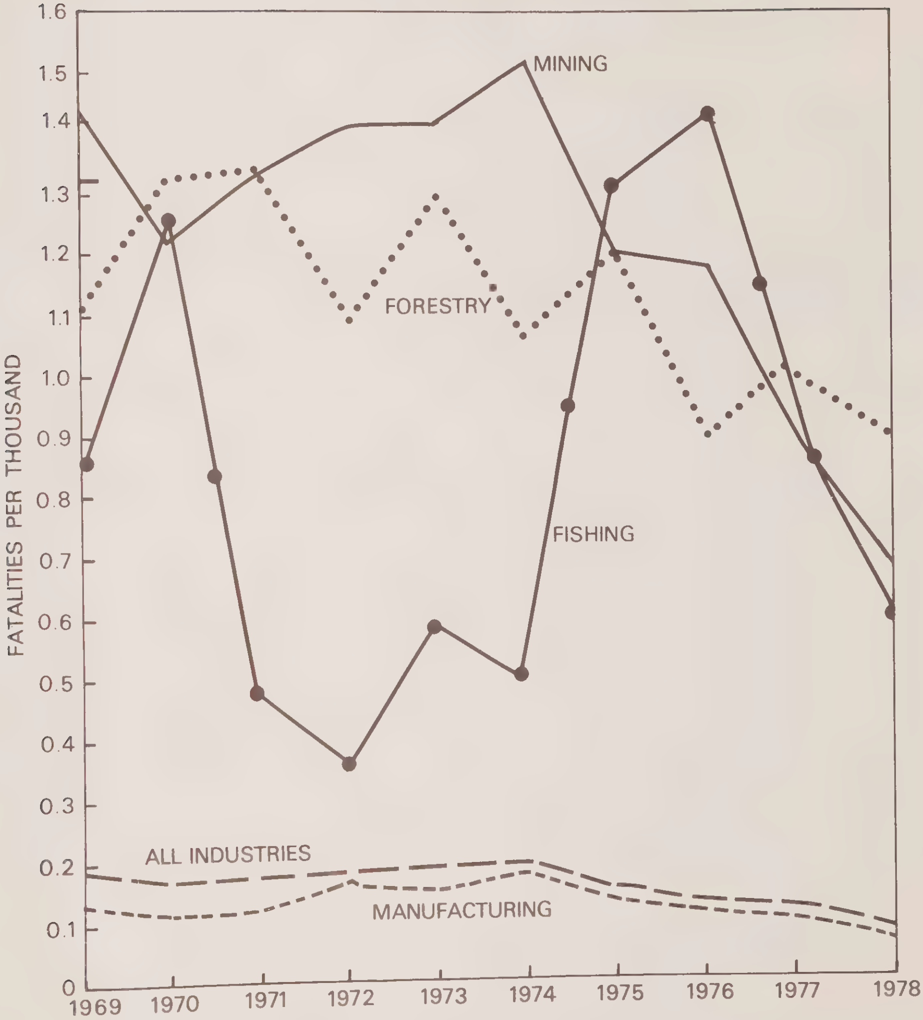
* Includes deaths arising out of occupational illnesses, and deaths of workers who were on pension for an earlier disabling injury.

† Fatality incidence rate equals number of cases per 100 000 workers. Rates calculated using Statistics Canada employment estimates. The rates may be understated because only 80% of workers in the Statistics Canada employment estimates are covered by workers' compensation.

p preliminary

FIGURE 4

## INDUSTRIAL FATALITIES




SOURCE: Statistics Canada

shops and surface facilities. Accident rates also vary among companies. While size appears to be a factor (Table 8) — larger companies presumably can afford safer working environments and better safety programs — other factors may contribute.

**Table 6. Nonfatal compensable injuries in metal and nonmetal mining companies in Ontario (1970-75)**

| Year | Man-hours worked* | Man-years at risk† | Injuries‡ | Injuries per 100 man-years at risk | Injuries per million man-hours worked |
|---|---|---|---|---|---|
| | (millions) | | | | |
| 1970 | 86.5 | 43 250 | 3 575 | 8.2 | 41.3 |
| 1971 | 82.6 | 41 300 | 3 318 | 8.0 | 40.1 |
| 1972 | 71.4 | 35 750 | 2 909 | 8.1 | 40.7 |
| 1973 | 66.8 | 33 400 | 3 220 | 9.6 | 48.2 |
| 1974 | 69.6 | 34 800 | 3 747 | 10.8 | 53.7 |
| Five-year totals | 376.9 | 188 500 | 16 789 | 8.9 | 44.5 |
| 1975 | 69.5 | 34 750 | 4 246 | 12.2 | 61.0 |

* From monthly work sheets of Mines Accident Prevention Association of Ontario (excluding prospectors).

† The number of persons at risk are estimated by dividing the man-hours worked by 2000.

‡ From annual reports of Mines Accident Prevention Association of Ontario (excluding prospectors).

**Table 7. Fatalities by metal group and class of work place (ranked by increasing fatality frequency for total operations)**

| Metal group | Total operations* | | Underground | | Open pit | | Reduction plants§ | | Shops and surface | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Employees† (1) | Frequency‡ (2) | Employees (3) | Frequency (4) | Employees (5) | Frequency (6) | Employees (7) | Frequency (8) | Employees (9) | Frequency (10) |
| Diamond drillers | 429 | 0.000 | 76 | 0.000 | – | – | – | – | 353 | 0.000 |
| Iron | 3 715 | 0.057 | 309 | 0.408 | 811 | 0.000 | 902 | 0.000 | 1 693 | 0.061 |
| Nickel | 22 946 | 0.162 | 11 178 | 0.308 | 136 | 0.000 | 8 297 | 0.035 | 3 335 | 0.094 |
| Miscellaneous industrials″ | 930 | 0.230 | 288 | 0.389 | 72 | 0.000 | 265 | 0.000 | 305 | 0.363 |
| Copper | 3 145 | 0.233 | 732 | 0.478 | 176 | 1.239 | 483 | 0.000 | 1 754 | 0.067 |
| Uranium | 1 632 | 0.389 | 854 | 0.638 | – | – | 198 | 0.495 | 580 | 0.000 |
| Miscellaneous metals | 282 | 0.399 | | | 5 | 0.000 | 187 | 0.528 | 90 | 0.000 |
| Gold | 3 396 | 0.419 | 1 960 | 0.711 | – | – | 377 | 0.000 | 1 059 | 0.000 |
| Shaft sinkers | 825 | 0.731 | 565 | 1.005 | – | – | 2 | 0.000 | 258 | 0.000 |
| Silver | 147 | 1.395 | 78 | 2.859 | – | – | 21 | 0.000 | 48 | 0.000 |
| All groups | 37 447 | 0.217 | 16 040 | 0.446 | 1 200 | 0.160 | 10 732 | 0.045 | 9 475 | 0.066 |

SOURCE: *Report of the Royal Commission on the Health and Safety of Workers in Mines*, Ham Commission, Province of Ontario, 1976.

* All company operations, including the sectors designated.

† Number of employees in the year 1974.

‡ Fatal injuries per million man-hours averaged over the five-years 1970-74.

§ Including concentrators, smelters, metallurgical plants.

″ Asbestos, nepheline syenite, talc, salt, silica.

Recently, the Federal-Provincial Commission on Mine Safety in Ontario recommended abolition of the bonus-incentive system of payment to miners, linking it to high accident rates. Initial reaction from union and industry spokesmen, however, indicates that neither party is convinced of the connection. Much more detailed study is evidently needed into the relationships between working conditions and accident rates. In this regard, a reporting system for near misses would add considerably to the data base.

**Table 8. Fatality frequencies by scale of operations underground**

| Scale of operation indicated by number of employees | Fatalities per million man-hours |
|---|---|
| 0–200 | 0.944 |
| 201–1,000 | 0.411 |
| 1000+ | 0.446 |

SOURCE: *Report of the Royal Commission on the Health and Safety of Workers in Mines*, Ham Commission, Province of Ontario, 1976.
NOTE: Frequencies are for the five-year period 1970-74.

Accident rates appear to be a function of specific working conditions, indicating that remedial action should be worked out on an individual mine basis. Recognition of the need for individual mine safety regulations has been embodied in mine development agreements in Saskatchewan, including detailed standards for protective equipment.

Additional measures have been advocated by the Federal-Provincial Commission on Mine Safety in Ontario — appointment of full-time, company-paid inspectors to enforce safety in the workplace, a major study on the relationship between serious accidents and lighting levels, greater responsibility for safety by the chief executive officer of mining firms, publication of safety performance records in each company's annual report, and the referencing of Ontario's *Health and Safety Act* directly into the *Canada Labour Code* — instead of referencing the regulations as exists now — to provide additional protection to Ontario uranium workers.

## Federal Jurisdiction

Federal jurisdiction over industrial health and safety covers 10 per cent of the Canadian labour force. In the mineral sector, federal jurisdiction is limited to uranium mining, crown corporations such as DEVCO, and indirectly, operations in the territories. Responsibility for health and safety at DEVCO is split between the Department of Regional Economic Expansion — the department responsible for managing the mine — and Labour Canada, under the *Labour Code* (Figure 5). DEVCO accident rates have, in some years, been unacceptably high, and some officials feel major changes in mining procedures are necessary if a significant reduction is to be achieved.

Jurisdiction over uranium mining is shared between the Atomic Energy Control Board and Labour Canada, with EMR and Health and Welfare Canada providing technical and policy support. Thus, similar health and safety problems at DEVCO and Eldorado are dealt with under quite different regulations and certainly under different authorities. The situation in the territories is even more complex. Mining health and safety is governed by territorial ordinances and rules, but administration of these laws is through the Department of Indian and Northern Affairs. Thus, the federal government has only indirect influence on health and safety regulations in the territories.

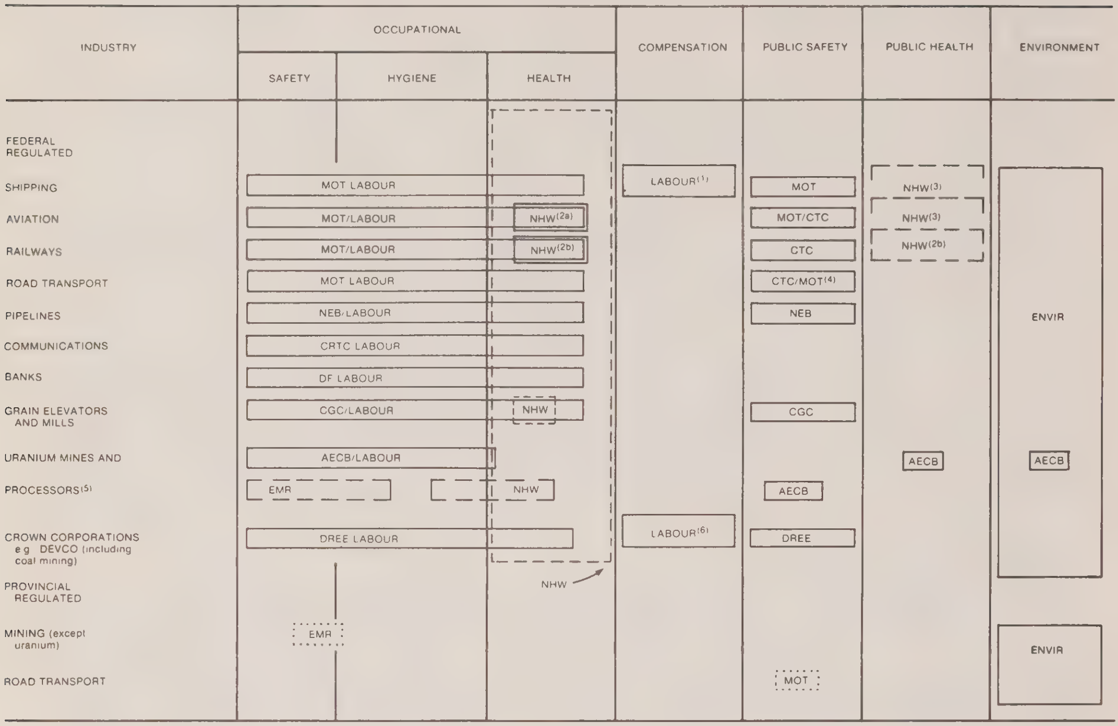
The situation clearly presents problems — inconsistency from one act to the next, bureaucratic struggles over jurisdiction, lack of accountability, variability of standards. Several provcinces are coordinating their approaches to health and safety problems. Ontario, Québec, Saskatchewan, Alberta and Newfoundland have centralized their systems of data collection, research, regulation, inspection and enforcement into single departments that treat health and safety as a problem common to all industry sectors. A similar streamlining is under consideration within the federal government.

Although the speed of change at the provincial level has left the federal government somewhat behind in its health and safety standards, it is ahead of almost all other efforts in research and development aimed at improving workplace health and safety. Within EMR, the

FIGURE 5

NATIONAL JURISDICTION AND RELATED ROLES IN OCCUPATIONAL HEALTH AND SAFETY — BY INDUSTRY

PRIME OCCUPATIONAL HEALTH AND SAFETY CONCERN




LEGEND

AECB — Atomic Energy Control Board

CGC — Canadian Grain Commission

CRTC — Canadian Radio and Television Commission

CTC — Canadian Transport Commission

DEVCO — Cape Breton Development Corporation

DF — Department of Finance

DREE — Department of Regional Economic Expansion

EMR Energy Mines and Resources

ENVIR Environment Canada

LABOUR - Labour Canada

MOT — Ministry of Transport

NEB — National Energy Board

NHW — Department of National Health and Welfare

——— regulatory

– – – supportive to Federal regulatory bodies

. Facilitative role nationally wherein legislative authority might rest with provinces

FOOTNOTES

(1) For Merchants Seaman's Compensation Act

(2a) For Civil Aviation Medicine

(2b) For Railway Work Camps

(3) For Quarantine Act

(4) For Motor Vehicle Safety

(5) Cooperative arrangement
- AECB licences, provincial inspect and enforce

(6) Government Employees Compensation Act

Explosives Branch administers regulations on the use of explosives in mining, while CANMET conducts research to reduce accidental explosion. CANMET is also working to reduce

fumes from diesel exhaust, and is studying noise and dust reduction, vibration effects on human health, and cost-effective ways of increasing illumination to reduce accidents in mines.

Close coordination must be maintained with all parties concerned with mining health and safety, to ensure consistent data gathering, analysis of problems and causes, effectiveness of corrective measures, etc. A national sample may reveal conclusions quite different from those indicated by data available in any one province.

Model national standards are under development for state-of-the-art applications of regulations and technology. These can be promulgated as guidelines and adopted by the federal government in those areas under its jurisdiction. Consultations will be held with the territories regarding incorporation of the guidelines into their mining regulations.

Regarding CANMET R&D — national research priorities will be defined, as well as the respective public and private roles therein. Since CANMET's existing areas of research — mitigation of diesel fumes, noise and dust reduction, vibration, more effective illumination — appear to stand up as high priorities, the major question is how much more can be done, and how quickly.

### Pensions

The inadequacy of pensions in the mining sector is emerging as a major factor in labour negotiations, as workers see the value of their retirement savings eroded by inflation. Pension plans provided in the mineral sector, as with much of the private sector, fall far short of ideal standards with respect to vesting and portability, adequacy of levels, and survivor benefits.

About 87.5 per cent of nonoffice employees in the mineral sector — in firms employing more than 500 and working under collective agreements — are covered by private pension plans. By comparison, less than 45 per cent of the country's total labour force is so covered, while in the public sector close to 90 per cent of all employees are covered.

But the extent to which mine workers receive benefits is far more limited than indicated by membership statistics. Because of vesting rules in employer-sponsored plans — which become established when an employee becomes entitled to a benefit — and because of the general lack of portability, only a small percentage of pension-plan members in the mining sector will ever receive benefits. With turnover rates of 10 to 30 per cent per year, and vesting terms in most private plans of 5 to 10 years, most employees in the mineral industry will never be eligible for a pension, except for the core group in long established mining communities that have achieved seniority.

Thus, although most pension plans in the mineral sector provide for 100 per cent employer contribution, employer pension costs will be much lower than where pensions are vested and must be fully funded. In plans where employees have the option of vesting or withdrawing contributions, they tend to withdraw at the first opportunity because of low interest rates offered in most private plans. By comparison, the Canada and Québec Pension Plans provide for immediate vesting and locking in, and are completely portable across Canada regardless of industry.

Few pension plans provide retirement incomes that are protected from serious erosion as a result of inflation. If the current level of inflation were to continue, workers retiring at age 65 today, without an indexed pension, would see the purchasing power of their income eroded by 80 per cent over the remainder of their retirement (average 12.8 years).

Generally, private plans provide options for surviving spouse benefits, but with the penalty of a reduced initial pension. Because of the penalty the retiree frequently rejects this option and the surviving spouse is denied any benefits from the plan.

Several measures are being taken to improve retirement income. Some unions, such as the Steelworkers, include improved pension benefits on a local-by-local basis as a prime bargaining

item in contract negotiations. Saskatchewan has legislated minimum pension benefits, so that not only employees in the mining industry, but also in all sectors covered by private pensions, will be subject to standards aimed at correcting the shortcomings mentioned above. However, these standards apply only in one province.

Some unions bargain pension benefits for an entire industry, as the Independent Woodworkers of America has done for Canadian forestry workers. Thus rights are transferable, provided individuals remain within the sector as members of the union. The federal government has initiated several studies, and has sponsored one federal-provincial conference on pensions. As an employer, it has established a model pension plan for its workers.

The danger of separate initiatives like these is that a patchwork of pension plans will proliferate in Canada, each with different standards, administrative structures, regulations and benefits, but without transferability. Moreover, mining is not the only industry subject to separate provincial jurisdictions plus the federal jurisdiction; government action on pensions should not be confined to mining, but must be tackled on an all-inclusive basis.

There appear to be two basic alternatives to ensure adequate retirement incomes: mandatory participation in a private pension plan that meets legislated minimum standards, or expansion of the Canada/Québec Pension Plans.

The first option may involve the adoption of standards for private coverage that have been established recently by the Canadian Life and Health Insurance Association. These standards include provisions for immediate vesting and locking in, complete portability with other plans, compulsory participation, minimum prescribed benefits, indexation of pensions-in-pay, and minimum benefits for surviving spouses.

The second alternative of expanded Canada/Québec Pension Plans could be considered simply to provide improved benefits in line with those outlined in the mandatory private coverage proposal. The advantage of improving the Canada Pension Plan rests with its universality.

Either alternative would be costly, perhaps double the cost of current pension arrangements. However, radical reform is needed now if we are to avoid impoverishing the next generation to pay for the current over-consumption of this generation. The mining industry should be particularly concerned, since the high turnover rates in the sector will deprive most employees of pensions.

Until the federal government's pension review — which is proceeding in consultation with the provinces — reaches a conclusion, the private sector may wish to continue to improve benefits under the pension schemes it sponsors.

# Environment

## Introduction

Like most industrial activities, mining and mineral processing can disrupt the environment. Mineral exploration, requiring access to large areas of land, sometimes conflicts with efforts to shield wilderness areas from any type of commercial activity. When a mineral deposit is discovered, mining — particularly open-pit mining — can degrade the immediate environment and have off-property effects on water quality. After the resource is mined, processing operations can affect water and air quality by dispersing contaminants in tailings or into the atmosphere. Acid rain, caused by the emission of sulphur dioxide and nitrogen oxides into the air, is one of the more serious environmental problems today.

The Canadian mineral industry has expressed concern about the effects of environmental regulations on its future development. It maintains that regulations are too strict, confused and overlapping, with uncoordinated administration from three levels of government. The industry also contends that the costs of meeting new environmental standards impose a major burden on company investment, affecting productive capacity and endangering its competitive position in international markets.

Governments, at all levels, have long recognized and worked towards eliminating the problems of varying standards and overlapping regulations and, thereby, have strived to minimize the degree of uncertainty associated with environmental regulations and enforcement. But it should be recognized that it is doubtful whether the uncertainty inherent in the system can be completely eliminated. The formulation of public policy on environmental issues is an ongoing process involving trade-offs that change over time. Environmental objectives are continuously weighed against other goals such as economic growth or energy security. As public perceptions of the relative value of various objectives change, so will the trade-offs confronting policy makers. Since change invariably creates uncertainty, some degree of uncertainty will always remain as part of policy formulation and regulation in this field.

Regarding the cost of meeting existing pollution standards in Canada, it is not apparent that this is imposing an insurmountable burden on the mineral industry. Standards in Canada are no more stringent than in the United States or Western Europe, and much less stringent than in Japan. They are more rigid than those in many less developed countries competing with Canadian mineral producers, but this does not appear to have seriously affected our competitive position as yet. However, more stringent controls in future — particularly on sulphur dioxide emissions — could have an impact on the smelting and refining industry, which is a major contributor to acid rain in this country.

## Acid Rain

While its ecological effects and health hazards are not yet fully understood, acid rain has undoubtedly contributed to the acidification of lakes and streams, is thought to be adversely affecting some agricultural crops and forest growth, and has the potential to contaminate drinking water systems. Unless the loading of acid rain into the environment can be arrested and reversed, this environmental degradation will continue.

Generally speaking, sulphur dioxide is responsible for about two thirds of the acidity in precipitation; the other one third is from nitrogen oxides. Sulphur dioxide is at present the prime target for control measures because it is the major source of acidity and also the more tractable of the two sources.

The problem is particularly acute in eastern Canada and the northeastern United States. The major sources of sulphur dioxide in eastern Canada are nonferrous metal smelters, which produce more than 40 per cent of the region's total emissions. In the United States, the major sources are fuel-fired electrical generating stations, which account for well over 60 per cent of all emissions.

It should be noted that sulphur dioxide emissions at some eastern Canadian nonferrous operations have been significantly reduced over the past decade. Emissions of the Inco smelter in Copper Cliff were reduced from 5500 tonnes per day in 1969 to 2270 tonnes per day in 1980. This smelter now successfully contains about 70 per cent of the sulphur in its feed. The Falconbridge nickel smelter, which emitted about 940 tonnes per day in 1969, now emits about 420 tonnes per day. Falconbridge's emission control system contains about 80 per cent of the sulphur in the ore processed. Other smelters control well over 85 per cent of the sulphur in their ore — zinc smelters at Valleyfield, Québec, and Timmins, Ontario, a lead smelter at Belledune, New Brunswick, and the copper smelter near Kamloops, British Columbia.

More than 50 per cent of the sulphur dioxide that falls in eastern Canada comes from the United States, while Canada's contribution to total American depositions is only about 10 per cent. To all intents and purposes, Canada is a recipient of transboundary pollution — it is subjected, in absolute and relative terms, to more pollution than it inflicts upon others.

This is a bilateral problem that can be solved only through cooperative action with the United States. In 1980, a Memorandum of Intent was signed by the two governments setting up the framework for negotiation of a transboundary air pollution agreement, the "core" of which would be a mutual obligation to reduce pollutant emissions. This obligation is consistent with the responsibility of states under international law to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states.

The direct costs of reducing sulphur dioxide emissions are expected to be high. The Department of the Environment (DOE) estimates that a capital investment of $620 million (in 1980 $) would be required by eastern Canadian nonferrous smelters to reduce emissions by 57 per cent. The cost of an 80 per cent reduction is estimated to be $1.0 billion. The net increase in annualized operating and capital costs for the 57 per cent reduction is estimated at $120 to $150 million (in 1980 $) — equivalent to 15¢ to 20¢ per pound of nickel and 5¢ to 8¢ per pound of copper. The annualized operating and capital costs for an 80 per cent reduction are estimated to exceed $200 million.

DOE estimates that, at capacity operations, an 80 per cent reduction in sulphur dioxide emissions from the Inco copper-nickel smelter at Sudbury would require an investment of $450 million (in 1980 $), with a net increase in annualized capital and operating costs of approximately $100 million. This is equivalent to about 20¢ to 30¢ per pound of nickel.

The costs outlined above are substantial. Who ultimately bears these additional costs will depend on the extent to which firms can pass on cost increases to consumers, the ability of firms to absorb additional costs through lower profits, and the ability of firms to pass on some of these costs in terms of lower wages. The "polluter pays" principle, where the firm and its customers pay for pollution abatement, has and continues to guide public policy making in this area.

The Canadian tax systems also have an important impact on the extent to which future pollution abatement costs are absorbed by the private sector. The existing systems contain

numerous provisions to substantially reduce after-tax costs to companies undertaking major capital expenditures. The net effect is that a major share of pollution abatement control costs are borne by governments in the form of reduced tax payments. The major provisions responsible for the reduction in taxes payable are: capital cost allowances, including accelerated depreciation allowances, earned depletion allowances, investment tax credits and processing allowances.

EMR has estimated that if Inco were to expend $600 million for capital expenditures (in 1980 $) in equal amounts of $100 million a year over a six-year period to meet pollution control requirements, the corporation could realize tax savings of $288 million in the first six years and an additional $90 million in the following six years due to the $600 million investment — in total, 63 per cent of the $600 million expended. If adjustments are made for the time value of money, tax savings would equal about 55 per cent of capital expenditures. In other words, society would bear more than half the costs of pollution abatement. And it cannot be assumed that the company and its shareholders would necessarily bear all the costs not borne by government. Some of the additional costs could be passed on to nickel consumers in the form of higher prices or to employees in the form of lower wage increases.

In addition to the direct costs they would create, tougher pollution standards would have an impact on the structure and performance of the Canadian nonferrous smelting industry. Moreover, this impact would differ among smelters depending on their concentrate characteristics, production processes and international competitive position.

Two cases in point are Inco's copper-nickel smelter in Sudbury and Noranda's copper smelter in Rouyn-Noranda. It is estimated that production costs at Sudbury are significantly lower than those at all other major operations in the non-Communist world. Even if Inco's Sudbury operations had to absorb significant additional pollution abatement costs, in the order of 20¢ or 30¢ per pound of nickel, the competitive position of the Sudbury Basin nickel mines would not be seriously affected — the rates-of-return on invested capital would still exceed those for other operations.

The same cannot be said of the Noranda smelter. This custom smelter's concentrate supply has been severely eroded in recent years, and it does not have a competitive advantage over other world smelters. Enforcement of tougher environmental standards could result in the curtailment of operations. This could seriously affect the economic base of the Rouyn-Noranda area — not only would smelter operations be reduced, but also the economic viability of small mines in the region could be compromised. It could also cause cutbacks at Canadian Copper Refineries in Montréal, which is dependent on the Noranda smelter for part of its feed.

The fact that profitability at Inco's Sudbury operations would still exceed that of its competition despite additional pollution abatement costs does not necessarily mean that the corporation has the financial capability to significantly reduce emissions at this time. In recent years, Inco has borrowed heavily and its debt/equity financial position has deteriorated significantly. Whether the company could repay those debts and at the same time raise significant new capital for pollution abatement activities is in doubt.

Apart from the costs — and the cost-sharing — involved in pollution abatement, governments and industry face another major problem. Current methods of reducing sulphur dioxide emissions create large quantities of byproduct sulphuric acid. The complete elimination of emissions from eastern Canadian smelters could result in the production of up to 3 million tonnes of sulphuric acid annually. This is equivalent to the total yearly consumption of sulphuric acid in this country, and is 10 times the level of current Canadian exports. Failure to sell this acid would substantially increase abatement costs, as there would be no offsetting revenues. Unfortunately, markets for byproduct sulphuric acid are very limited.

The ability to sell sulphuric acid and transport it economically depends largely upon the location of the plant with respect to its market. When sulphuric acid is difficult to market it may be used to make phosphate fertilizers. However, this use produces a large tonnage of gypsum tailings and necessitates the entry of the smelting company into the fertilizer business. Zinc smelters now have the option of treating at least a portion of their concentrate feed using the Sherritt-Cominco pressure leach process, which fixes sulphide sulphur in elemental form. Thus, they can expand zinc production without the consequent need to produce and sell more sulphuric acid. Copper and nickel producers, however, do not have the same flexibility. They have, through the development of flash and continuous smelting processes using oxygen enriched process air, so reduced gas volumes and raised sulphur dioxide concentration that sulphur dioxide either can be compressed to liquid or converted to elemental sulphur. Unfortunately, the storage of liquefied sulphur dioxide is difficult and markets are very limited while the production of elemental sulphur is very expensive, particularly when compared to the production of sulphuric acid.

## Other Issues

In addition to sulphur dioxide emissions, mining and mineral processing activities can affect the quality of the air, soil and water in a number of other ways. In terms of air quality, metallurgical plants can emit heavy metals, inorganic and organic compounds, and many gaseous emissions other than sulphur dioxide. Technology offers the promise of nearly pollution-free processes, but until these are fully developed and commercially proven, governments will, as in the case of sulphur dioxide emissions, face trade-offs between industrial activity and environmental quality.

The degradation of the terrestrial environment is also of concern. But due to the remote location of many mining and milling operations, the visual impact on the landscape — aesthetic pollution — is minimal. This, though, is not the case for operations, particularly sand and gravel extraction, that are located in or near more heavily populated areas. However, land reclamation following mining is now becoming more commonplace and does not appear to be excessively costly in most areas.

The most significant aspect of soil pollution is potential groundwater contamination from tailings disposal and effluent impoundments, with possible seepage and migration to underlying aquifers, or surface runoff that could pollute major drainage basins. In the fragile northern environment, with slow natural recovery rates due to low temperatures for much of the year, this is an important consideration.

Open-pit mining also can disrupt the natural hydrologic system over large areas, inducing a number of further deleterious effects on vegetation and wildlife. Surface waters sometimes can be contaminated by runoff, containing toxic materials, from tailings piles or impoundment ponds. Tailings disposal in lakes can destroy fish habitat, contribute to eutrophication and generally upset the local ecology. In addition, oceans are susceptible to pollution from tailings disposal or other runoffs arising from insufficient water circulation and movement in coastal areas.

Significant land-use problems can also result from mining activity. In remote areas, these problems tend to appear as disruptions to food supplies and lifestyles of indigenous people. In more settled regions, mining can remove land from agricultural production, scar the landscape and conflict with recreational uses of the land.

It is fully evident that environmental factors must be taken into consideration in decisions relating to the development and operation of mineral facilities. Legislation to ensure that this occurs is already largely in place. For example, the federal *Fisheries Act* gives broad powers to

the Minister of Fisheries and Oceans to ensure the integrity of all Canadian fisheries. Another measure in this area is federal land use policy, which involves Agriculture Canada, Environment Canada and other departments. Canadian mineral developments are subjected to stringent pollution regulations. Nevertheless, research and development dealing with problems of air, land and water pollution will be further promoted, and preplanning for land use and reclamation needs will continue to be encouraged.

# Further Processing of Mineral Resources

## Introduction

Further processing of mineral resources has been a continuing objective of Canadian public policy, because it provides employment, increases value added, promotes regional development and increases tax revenues. Most provincial mines acts require processing of resources before export but contain grounds for waiving the requirement. In 1974 the federal government amended the *Export and Import Permits Act* to support upgrading of resources. In addition, the extent of further processing in Canada is a criterion used by FIRA in assessing mineral development proposals.

Despite these measures and the policy that underlies them, about one half of Canada's nonferrous mine production still leaves the country in relatively unprocessed form (Figures 1, 2 and 3). And although Canada's position at the Tokyo round of General Agreement on Tariffs and Trade (GATT) negotiations was based on the same policy, efforts to reduce foreign tariff barriers to more processed products have not been entirely successful.

On the surface, it would appear that Canada's best opportunity for further processing relates to the high volume of nonferrous mineral concentrate that is exported. If all this concentrate were smelted and refined in Canada, approximately 3300 jobs would be created in five new world-scale plants costing approximately $1.8 billion (in 1980 $). The location of some of this activity in areas of high unemployment, such as northeastern New Brunswick and the Yukon, would also further the federal government's regional employment objectives.

Aside from direct employment benefits, additional processing capacity could offer marketing and cost advantages to industry. The products of a west-coast copper smelter and refinery could be marketed throughout the world, providing greater options for those British Columbia mines that are locked in to long-term contracts with specific Japanese smelters. A domestic smelter could treat mineral concentrates at lower concentrations of metal than foreign smelters will buy; savings in milling costs and additional revenues from lower cut-off grades would be possible with cooperation between mining and smelting operations. Moreover, Canadian smelters would obtain additional revenue from byproducts for which overseas smelters may not provide full credit when buying concentrate.

World smelting and refining overcapacity is expected to last to the mid-1980s, after which substantial new and replacement capacity for primary nonferrous metal processing probably will be required. Whether a significant portion of this new capacity will be built here depends on the extent to which Canada can remove or reduce the constraints that have prevented further processing in the past.

The 100 000 tonne Brunswick zinc smelter[1] will come into production in the mid-1980s, to coincide with the expected upturn in market conditions for zinc metal. This expected improvement, combined with a favourable tax regime, should be sufficient to ensure that the smelter will be financially viable.

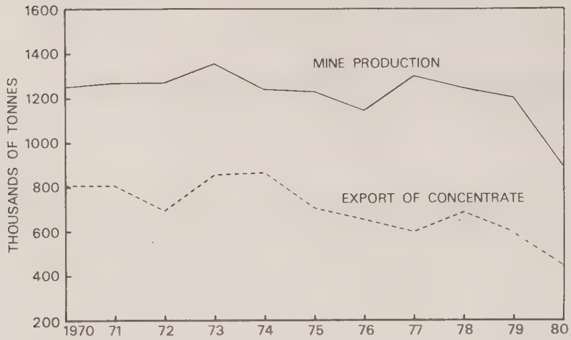
## The Constraints

The policies of resource-poor countries to obtain mineral resources, reinforced by tariff and nontariff barriers, are the main constraints to development of new Canadian smelters and

[1] Development plans were announced in November 1981.

FIGURE 1

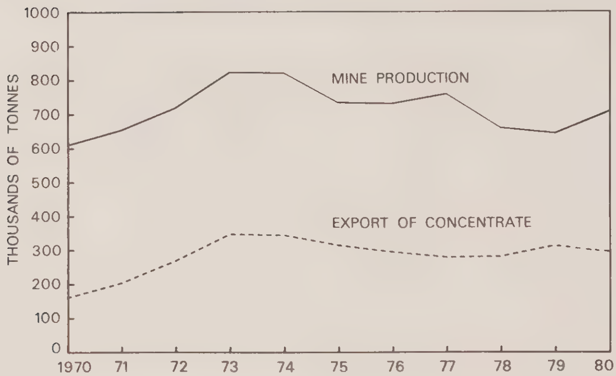
ZINC PRODUCTION IN CANADA




SOURCE: Mineral Policy Sector, EMR

FIGURE 2

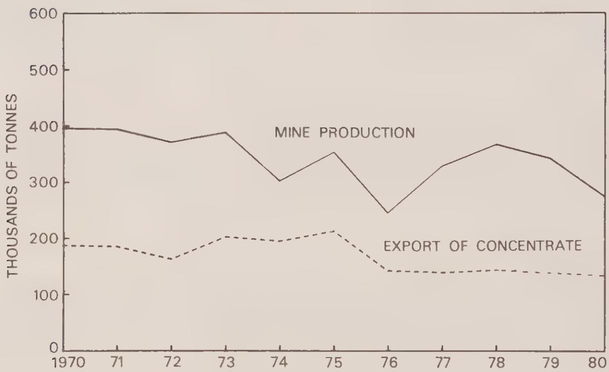
COPPER PRODUCTION IN CANADA




SOURCE: Mineral Policy Sector, EMR

FIGURE 3

LEAD PRODUCTION IN CANADA




SOURCE: Mineral Policy Sector, EMR

refineries. For example, Japan's current tariff of 4.8 per cent on refined copper at 1980 prices (Figures 4, 5 and 6), combined with company procurement practices and a domestic pricing system that encourages imports of concentrate, virtually prohibits Canadian exports of metal to that country. Moreover, the level of value added in the smelting and refining of copper, lead and zinc is low relative to the final product price. Hence, *effective* tariff rates are much higher than *nominal* tariff rates (Table 1).

Thus the 4.8 per cent *nominal* tariff rate on refined copper entering Japan amounts to an *effective* rate of almost 32 per cent because raw material and other inputs enter Japan duty-free. Effective rates of protection on primary zinc have been calculated at 14 per cent, and on refined lead at more than 25 per cent. Effective tariff rates on more finished copper products

FIGURE 4

CANADIAN ZINC EXPORTS-1980

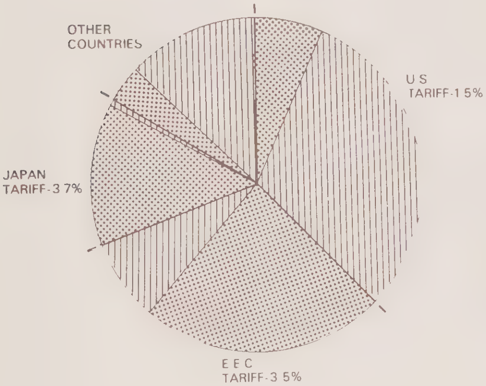



FIGURE 5

CANADIAN COPPER EXPORTS -1980

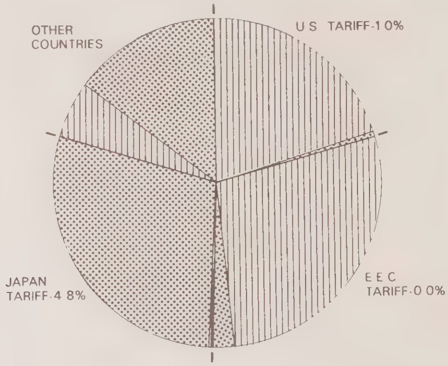



FIGURE 6

CANADIAN LEAD EXPORTS-1980

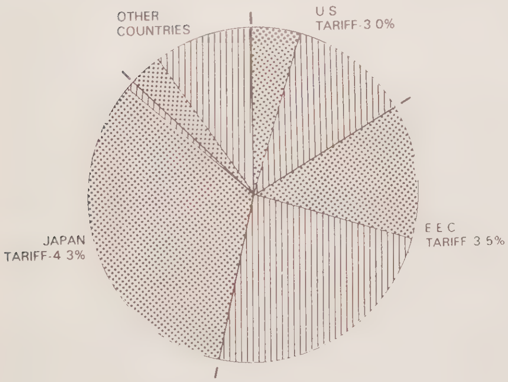


**Table 1. Japan—post Tokyo tariff rates**

| Commodity | Nominal tariff rate | Effective tariff rate |
|---|---|---|
| | (%) | |
| Refined copper | 4.8 | 31.6 |
| Refined zinc | 3.7 | 14.3 |
| Refined lead | 4.3 | 25.6 |

NOTE: Based on July 1980 price-cost relationship.

such as tubes, brass shapes and wire are considerably lower at 5 to 6 per cent, favouring the export of more finished goods to Japan in preference to smelted and refined products.

Thus foreign trade policies provide Canadian mines with a strong incentive to export concentrate to enhance mine profitability. For example, a policy to force Canadian mines to smelt and refine copper concentrate in Canada before sending the metal to Japan could impose an economic burden of $50 to $85 million per year, due not only to the tariffs that would be borne by the Canadian smelters, but also to the higher costs of processing in Canada compared to the favourable smelter charges offered abroad. Under present market conditions, if all zinc concentrate were smelted in this country, an additional $80 to $100 million penalty could be imposed on the Canadian economy.

Foreign market barriers are offset to some extent by favourable provincial electricity rates and generous federal tax incentives. The cost of such incentives, however, is very high because of the capital-intensive nature of smelting and refining. The capital cost per job created varies from $46 000 for a zinc smelter to $785 000 for an aluminum smelter, while the cost to the federal and provincial governments in foregone taxes, i.e. tax expenditures, ranges between $285 000 and $40 000 per job (Table 2). When this is combined with energy "subsidies" avail-

**Table 2. Capital costs and tax expenditures per employee***

| | Capital cost for minimum world scale plant | Capacity | Employment | Cost per job | Tax expenditure per job† |
|---|---|---|---|---|---|
| | ($ millions) | (thousand tonnes) | | ($ thousands) | |
| Zinc smelter | 185 | 100 | 400 | 460 | 285 |
| Copper smelter (pyro) and refinery | 240 | 80 | 375 | 625 | 325 |
| Lead smelter-refinery (sinter/blast, electrolytic refining) | 145 | 100 | 275 | 525 | 315 |
| Aluminum smelter | 550 | 200 | 700 | 785 | 400 |
| Mining (open-pit copper) | – | – | – | 260 | 100 |
| Wire and cable mill | – | – | – | 120 | 50 |
| Brass mill | – | – | – | 178 | 70 |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

* 1980 Canadian $.

† Calculated on a flow through basis.

able to the industry through current oil and gas prices and favourable electricity rates from provinces, the total public cost per job created in smelting and refining ranges between $381 000 and $959 000 (Table 3). Yet without these incentives the private sector would not regard most projects as being financially viable.

**Table 3. Smelting and refining plants energy (electricity and petroleum) costs compared to wage benefits: possible scenarios**

| Plant | Annual energy consumption | Cost of energy: Opportunity cost | Cost of energy: Actual cost | Labour income | Energy at opportunity-cost divided by wage costs × 100 | Energy subsidy as percentage of wage costs | Annual energy subsidy per job | Net present value—energy subsidy plus tax expenditure per job (7.5% disc.) |
|---|---|---|---|---|---|---|---|---|
| | | ($ thousands) | | | (%) | | $ | |
| Zinc smelter (90 000 tonnes/yr output) | 360 mWh/yr<br>Fuel 8 600 tonnes/yr | 14.4<br>1.8†<br>16.2 | 9†<br>1.3§<br>10.3 | 10.6 | 153 | 56 | 14 750 | 435 000 |
| Copper smelter and refinery (100 000 T output) B.C. location | 68.5 mWh/yr<br>Fuel 20.6 M Btu/tonne | 2**<br>11.8″<br>13.9 | 1.17††<br>6π<br>7.17 | 14.5 | 96 | 46 | 13 900 | 466 700 |
| Lead smelter and refinery (100 000 tonnes) | 340 kWh/tonne<br>Oil 13 280 tonnes/yr | 1**<br>2.7†<br>3.7 | 0.58††<br>1.7<br>2.3 | 6.2 | 60 | 23 | 6 500 | 381 000 |
| Aluminum smelter (200 000 tonnes/yr) | 13 700 kWh/tonne<br>Fuel 38 000 tonnes/yr | 82.2<br>7.78†<br>89.98 | 46.6††<br>4.99†<br>51.59 | 21 | 428 | 183 | 54 800 | 959 000 |

SOURCE: Resource Strategy and Economic Analysis, EMR.

NOTE: All prices and costs in 1980 Canadian $.

* Opportunity cost of power is 40 mills.

† World price of heavy fuel oil is taken at Can. $28.

‡ Offered price of power is 25 mills.

§ Domestic price of heavy fuel oil is $18/barrel.

″ Export price of natural gas is $5.72/thousand cubic feet.

π Delivered price of natural gas is $2.90/thousand cubic feet.

** Calculated at 30 mills.

†† Calculated at 17 mills.

## The Opportunities

Because of the level of tax expenditures and other subsidies, governments should determine whether the public cost of job creation in smelting and refining is worthwhile. In certain instances, such as the recently-announced New Brunswick zinc smelter, the economic benefits far outweigh public costs. Generally, though, it is a very expensive way to create employment for regional development purposes; for each case, other opportunities that pay a higher social rate-of-return and generate greater employment at lower public cost should be considered. For example, Canada now has enough smelting capacity to support a considerably larger fabricating and finished products industry, and the tax expenditures needed to support job creation in fabricating are much less than those required in smelting and refining. Substantial new opportunities exist in the mining machinery and equipment industry (see *Mineral Machinery and*

*Equipment*). In addition, there should be a few major smelter-refinery projects that will become viable in Canada over the next 10 to 15 years, given changes in market conditions, easing of foreign trade barriers and improvements in technology that would not require government subsidies. Moreover, there are policies that could be pursued to enhance the competitive position of future Canadian smelting capacity. These include:

- Research and development on more efficient, less energy-intensive and less polluting smelting and refining technologies;
- Achievement of economies of scale by coordinating investment decisions and overseas delivery contracts to pool concentrate through a commonly owned smelter;
- Improved market intelligence and analysis, to determine when market forces will make investments viable, rather than relying on government subsidies to make smelter projects financially attractive; and
- Reduced competition among provinces seeking to attract smelting capacity with tax concessions and subsidized electricity prices.

A cost-benefit analysis of a hypothetical investment proposal can illustrate the application of such policies. Zinc smelters are highly capital intensive; this one would generate 400 jobs at an expected cost of $152 million (in 1980 $). The level of government tax expenditure to induce this investment is quite generous (Table 4).

**Table 4. Zinc smelter financial and economic analysis***

| Discount rates | 7.5% | 15% |
|---|---|---|
| | ($ millions)† | |
| Capital cost (net present value) | 152 | 128 |
| Government tax expenditure (first 6 years) | 94 | 70 |
| Percentage capital cost borne by tax system | 62% | 55% |
| Tax revenue from smelter (20 years) | | |
| Federal | −45 | −54 |
| Provincial | 11.5 | 3.3 |
| Wages | 79 | 48 |
| Profit to corporation | 64 | 12 |
| | (%) | |
| Rate-of-return (before tax) | 9.8 (real) | |
| Rate-of-return (after tax) | 14.5 (real) | |

SOURCE: Resource Strategy and Economic Analysis Branch and CANMET, EMR.

* Zinc prices of approximately 50¢/lb (1980 Can. $) were assumed.

† 1980 $.

The project would pay an economic rate-of-return of 9.8 per cent, higher than the social discount rate of 7.5 per cent used by government to determine whether investments are beneficial to society. It should be considered viable and therefore does not require additional government assistance. Nevertheless, the project return is highly sensitive to changes in zinc prices; because of market uncertainty and general corporate practice, private companies often insist on a 15 per cent real rate-of-return after taxes, or a 28 per cent nominal rate-of-return. Federal and provincial tax expenditure raises the *financial* rate-of-return to 14.5 per cent (real).

However, new technologies developed from current research efforts could raise the project's rates-of-return quite significantly, if preliminary results of two new zinc smelting pro-

cesses can be maintained in a full-scale plant. The Sherritt-Cominco pressure leach process and the Research and Productivity Council (RPC) sulphation roast method both show much higher rates-of-return — 16 to 17 per cent — because of much higher rates of metal recovery. However, both technologies are in early stages of development. The RPC process is ready to be piloted, but because of the high cost — \$25 to \$30 million — plus other factors, the private sector has been reluctant to invest in an RPC pilot plant. Current CANMET-Sherritt tests may indicate that the Sherritt-Cominco process is the preferred technology for smelting bulk zinc concentrate. Moreover, this process produces elemental sulphur as a byproduct, thereby eliminating the costs of reducing sulphur dioxide emissions or disposing of sulphuric acid. All in all, government efforts to support R&D for new smelting technologies appear highly desirable.

Economies of scale in each technology could raise the rate-of-return an additional three percentage points. Unfortunately, Canadian companies, dealing at arm's length with one another, are unlikely to cooperate by pooling concentrate through a commonly owned smelter, and common ownership would be necessary to increase tax advantages as well as operating efficiency and recovery. Instead, Nanisivik is shipping zinc concentrate to Europe on long-term contracts — and Polaris soon will be — while substantial quantities of zinc concentrate continue to flow down the St. Lawrence River. If Arctic zinc concentrate were smelted at an eastern Canadian location, economies of scale and greater smelter profitability could be achieved.

Current contract terms offered by overseas smelters will become less attractive as concessionary energy contracts in EEC countries expire, and as excess smelter capacity is reduced through normal market growth and closure of uneconomic smelters. In this context, improved economic analysis of Canada's competitive position would provide a better indication of expected trends in smelter contract terms, and would indicate to government and industry when the timing for investment in Canada is appropriate.

Finally, a greater degree of federal-provincial coordination of electricity pricing policies, as well as tax concessions, would avoid deleterious interprovincial bidding for new smelter capacity. As the analysis above indicates, current concessions are already generous and will be reviewed in the general context of tax concessions.

## Possible Measures

Measures to assist further processing should be assessed on a case-by-case basis. CANMET - private-sector research into environmentally safe, efficient nonferrous smelting technologies is being intensified. Such activities can proceed in tandem with efforts to maximize Canadian content of smelter machinery and equipment for domestic and export sales. CANMET's budget is being examined with a view to providing support to more intensive R&D on processing technologies, where such technologies constitute a public good, where expected returns exceed the social discount rate, and where control of the technology will remain in Canada, stimulating the Canadian equipment industry.

No new programs of financial assistance to attract new smelters and refineries are necessary. The capital-intensive bias of the existing tax system is of concern, as is interprovincial bidding through tax concessions and energy pricing. Opportunity cost pricing of energy for energy-intensive metal exports should be considered in any cost-benefit analysis of future processing proposals.

Possible measures to provide access in foreign markets for higher value-added manufactured goods produced from Canadian metals are outlined in the chapter, *International Marketing of Minerals*.

# Mineral Machinery and Equipment

## Introduction

Although Canada is the world's third largest mineral producer, domestic production of mining equipment and machinery is disproportionately small, providing less than half the mining industry's requirements and leaving the rest of this large market to foreign manufacturers. The situation underlines a general concern that mineral development in this country over the years has not generated sufficient economic spinoffs. The possibility of strengthening and revitalizing Canada's mining machinery and equipment industry therefore requires examination.

## Present State of the Industry

In 1980 the Canadian mining industry spent $1200 million on machinery, equipment and parts — $800 million on new items, and $400 million on replacement parts and attachments. The Canadian market for these goods is currently the third largest in the world, following the United States and U.S.S.R. Table 1 gives a synopsis of the Canadian mining machinery market for 1977, 1978 and 1980. Purchases were much lower in 1978, reflecting the cyclical nature of mining activity. Specialized mining process equipment — Class A products[1] — accounted for 40 per cent of total purchases in 1978.

Canadian imports of mining machinery and equipment in 1980 totalled about $640 million — 53 per cent of all such purchases by the mining industry. Canada clearly is not even close to self-sufficiency here. The Canadian machinery industry does better providing parts and attachments than supplying new capital equipment — 48 per cent import content for Class C items,

[1] See accompanying sidebar, *Classes of Mining Equipment*.

**Table 1. Synopsis of the Canadian mining machinery market**

| | 1977 | 1978 | 1980 |
|---|---|---|---|
| | ($ millions) | | |
| Specialized mining machinery and equipment* | – | 289 | – |
| All mining machinery, equipment and parts, including general purpose machinery† | 900 | 717 | 1200 |
| Total capital and repair expenditures on machinery and equipment, including maintenance services‡ | 1400 | 1200 | 1900 |
| Total capital and repair expenditures | 2300 | 1800 | 3200 |

*Comparisons*

Total U.S. market for mining equipment was $U.S. 3820 million (nearly five times as large in 1977).

NOTE: All these categories exclude expenditures made by the primary metal sector but contain a significant amount of smelting and refining expenditures made by integrated mining companies.

* ITC estimate.

† EMR estimate, removing the 60% labour content from the repair expenditure component of the Statistics Canada capital and repair expenditure evaluation for 1977, 1978 and 1980.

‡ Statistics Canada 61-205.

compared to 56 per cent import content for Class A and B items. Canadian content is highest in beneficiation plant equipment, 65 per cent, and underground mining equipment, 50 per cent.

In contrast, the Canadian industry provides less than 30 per cent of the equipment required by surface mining (Table 2). This reflects the historical predominance in Canada of underground, hard-rock mining. Our relative strength in milling and concentrating machinery is due partly to the fact that metal ores need more complex beneficiation than nonmetal ores, and Canada extracts considerably more metals in proportion to nonmetals than the United States. A comparison of U.S. and Canadian mining equipment markets is presented in Table 3.

**Table 2. Canadian content of machinery and equipment used in Canadian mineral processing operations**

| | New investment | Repair and maintenance |
|---|---|---|
| | (%) | |
| Open pit | 28 | 32 |
| Underground | 50 | 51 |
| Mill and concentrator | 65 | 68 |
| Smelting-refining | 33* | 86 |

SOURCE: Mining Association of Canada – Energy, Mines and Resources Canada Task Force on Mining Machinery.

* This figure depends on the process.

**Table 3. Comparison of U.S. and Canadian mining equipment markets by major segments (1977)**

| | | | |
|---|---|---|---|
| *Canada* | (%) | | (Can. $ millions) |
| Underground mining equipment | 25 | or | 225 |
| Surface mining equipment | 20 | or | 180 |
| Mineral beneficiation plant equipment* | 20 | or | 180 |
| Mining equipment parts and attachments | 35 | or | 315 |
| | 100 | | 900 |
| *United States* | | | |
| Underground mining equipment | 17 | or | 639 |
| Surface mining equipment | 49 | or | 1883 |
| Mineral beneficiation plant equipment | 10 | or | 380 |
| Mining equipment parts and attachments | 24 | or | 918 |
| | 100 | | 3820 |

SOURCES: Based on Frost & Sullivan Study of the Mining Equipment Market (New York). Statistics Canada, and various trade magazines.

NOTE: The mining equipment market as discussed in this table covers all machinery, equipment and parts (including machinery of general application) that are bought by the mining industry. Unless otherwise indicated smelting and refining machinery market is not included.

* Also includes some nonferrous smelting and refining equipment.

Because they apply to all product classes, the Canadian content figures in Table 2 hide the poor results achieved by the Canadian industry in the area of sophisticated mining equipment. By 1978 Canadian-made equipment, as a ratio of total equipment purchased, had *shrunk to a mere 27 per cent*, from almost 50 per cent in 1965. Although this was offset to some extent by a shift of efforts towards export markets, this gain has been realized at the expense of the sector's overall high-technology capability.

What, then, ails the Canadian mining equipment industry? Generally speaking, it is fragmented, with an incomplete range of products and capabilities, and short production runs. Its

weak development in this country is associated with the ownership structure of the industry, and the nature of import competition.

Low or zero tariff protection has encouraged specialization in the industry, which in turn has reduced the range and Canadian content of products. To reduce unit cost, the Canadian branch-plant industry has evolved towards *an assembly type of operation* specializing in structural and low-technology components. Sophisticated controls and other high-technology components are provided mostly through the parent organization.

### Classes of Mining Equipment

The broad range of capital goods required by the mining industry falls into three general categories:

*Class A*

Sophisticated, specialized process equipment used almost exclusively by the mining industry — drilling systems; excavating, dredging and loading equipment; beneficiation plant equipment; smelting and refining equipment. This category covers from 40 to 50 per cent of the mining machinery market.

*Class B*

A variety of general-application equipment used in many industries, of which mining is only one. This material mainly comprises standard, off-the-shelf components used in many kinds of industrial processes — electric and diesel motors, pumps, compressors, valves, hoists and winches, wire and cable, chains, tubes, structural steel and plates. This equipment can be sold individually or as a component of an integrated system.

*Class C*

Custom-made, low-level technology components or parts that are used exclusively in the mining industry. These include drill-string components, custom castings, and bulky or custom-fabricated equipment — tanks, hoppers, bins, vessels, etc.

At the same time, the R&D function of the Canadian industry has been severely truncated; most of the recently introduced types of equipment, e.g. load-haul-dump (LHD) vehicles, raise borers, potash continuous miners, were brought into Canada in the development stages and modified by Canadian subsidiaries. The revisions were then returned to the U.S. parent company for redesign and patent of the related equipment, which was then re-exported to Canada. In some instances, Canadian subsidiaries were licensed to assemble and manufacture components. It is true that development, production and marketing mandates have been allocated to some Canadian subsidiaries over the past 10 years. But overall, Canadian subsidiary responsibility over the parent product lines has so far remained marginal. As a result, the Canadian branch-plant industry expertise is biased towards the production of low-level technology equipment and components, a specialization that leaves it vulnerable to price competition. A particular exception is the Canadian capability in exploration equipment.

Mining technology is very system-oriented, i.e. a large set of components is required to perform any given process. In order to reduce the risks related to process integration, mining companies usually prefer to procure technology packages instead of individual pieces of equipment. In other words, mining firms tend to deal only with organizations offering a complete system integration capability. Since it is not in control of the technology necessary to develop integrated machinery systems, the Canadian branch plant is more often than not limited to the role of subcontractor to the parent organization, which usually retains the more challenging — and lucrative — process engineering assignments. One consequence of this situation is that the export capability of the Canadian subsidiary is reduced by the parent's control over marketing and investment strategies.

In contrast, the Canadian industry's position is much stronger with respect to bulky and custom-made, low-technology machinery and equipment (Table 4). Virtually all the mining industry's metal fabrication requirements are met by domestic manufacturers, who supply tubular goods, structural steel, fitting valves, bins and hoppers, tanks and other vessels, as well

Table 4. **Canadian content of machinery and equipment used in Canadian mineral processing operations, by degree of sophistication and specialization**

| | Size of the Canadian machinery industry in relation to the size of the domestic market | Exports as a percentage of total domestic shipments | Import penetration of the Canadian market |
|---|---|---|---|
| *Specialized mineral processing equipment and parts* | | (%) | |
| Rock drilling and earth boring machinery, drill bits and parts | 75–80 | 58–77 | 78–90 |
| Excavating dredging and loading equip., and parts | 19–21 | 45–99 | 91–100 |
| Mining, quarrying and ore dressing machinery and equipment and parts | 48–67 | 37–75 | 73–93 |
| *Selected equipment of general application used in the mineral processing industry* | | | |
| Bins and hoppers, tanks | 93 | 6 | 14 |
| Hoists, lifts and winches | 67 | 31 | 54 |
| Pumps | 67 | 30 | 53 |
| Conveyors and conveying systems | 95 | 9 | 14 |
| Industrial furnaces, kilns and ovens | 36 | 39 | 78 |

SOURCES: Statistics Canada Catalogue 31-529, Apparent Domestic Availability of Selected Manufacturing Products for 1975 and 1977.

as more than 80 per cent of the industry's conveyor systems. The Canadian mining equipment industry also has good capability in the manufacture of some types of pumps and compressors, as well as hoists, lifts and winches.

## Future Opportunities

Since the size and technological capability of the Canadian mining machinery industry fall far short of meeting current domestic mining requirements (Table 5), how will this industry fare in the coming years? The most significant market forces likely to affect the industry during the next decade are: (a) a surge in demand for equipment common to the energy and nonenergy mineral sectors, due to tar-sands development; (b) continued strength in the market for open-pit mining equipment; (c) a growing need for energy efficiency that will rapidly make the existing stock of inefficient machinery obsolete; (d) the increasing substitution of capital for labour, resulting from skilled labour shortages and health and safety issues; and (e) environmental regulations. Marketing opportunities therefore are heavily biased towards:

- Surface mining equipment that is energy efficient and that boosts labour productivity; and
- The higher end of the technology spectrum for all categories of equipment. Increased automation and recovery rates, and overall energy efficiency, are the priorities.

Some of the most outstanding manufacturing opportunities of the next decade are shown in Tables 6 and 7. Except for bulk conveyors and bulky Class C products generally, Canadian

**Table 5. Present manufacturing capability of the Canadian mining machinery industry**

| | Overall rating | Comments |
|---|---|---|
| SPECIALIZED MINING/MINERAL PROCESSING EQUIPMENT | LOW TO FAIR | |
| *Exploration equipment* | *High* | Wide range of high quality geophysical instruments and diamond drilling equipment |
| *Underground mining equipment* | *Fair* | |
| Drilling and face breaking | Fair | Incomplete range: no continuous miners, no hydraulic drilling equipment; rather low-level technology |
| Loading and hauling | Fair | Incomplete range: no continuous loading and hauling systems; strong in LHD, head frames |
| Support and other | Fair | Incomplete range and rather low-level technology; no coal mining equipment |
| *Surface mining equipment* | *Low* | |
| Drilling and blasting | Very low | No Canadian capability |
| Stripping and loading | Low | Very incomplete range (no wire shovels, scraper-haulers, front-end loaders, bulldozers) and high import content |
| Hauling | Fair | Incomplete range and high import content |
| *Mineral beneficiation equipment* | *Fair* | |
| Screening and classifying | Fair | Fair range but rather low-level technology in a low growth area |
| Crushing and grinding | Fair | Fair range but lack of sophisticated control devices |
| Flotation, separation, thickening, drying | Low | Inadequate range of products in a high growth area |
| Air-liquid quality control (filters, scrubbers) | Low | Inadequate range of products |
| Bulk material handling | High | Wide range of conveying systems but limited capacity for stacker-reclaimers |
| *Smelting and refining equipment* | *Low* | Inadequate range of products (e.g. Inco TBRC technology licensed to Dravo U.S.) |
| SPECIALIZED MINING EQUIPMENT PARTS AND SUPPLIES | HIGH | Adequate product range, except for open-pit equipment; competitive quality and prices (e.g. custom castings and machine shops) |
| GENERAL PURPOSE EQUIPMENT WITH MINING APPLICATIONS | FAIR | |
| *Industrial process equipment* | *Low-fair* | Pressure vessels, steam generating equipment available but otherwise incomplete range |
| *Metal fabrication* | *High* | Wide variety of products available: tanks, bins, hoppers, mining hardware, etc. |
| *Pumps compressors, fans, heaters* | *Fair* | Large size high capacity items not made in Canada |
| *Motors, drives and mechanical transmission* | *Low* | Diesel motors, drivers, clutches are not available in sufficient quantity |
| *Electric and other equipment* | *Fair* | Good electric equipment capability albeit high import content |

SOURCE: Resource and Economic Analysis Branch, EMR.

**Table 6. Mining machinery market segments forecast to 1990**

| | Number of times above the average growth rate in the United States and Canada | Canadian manufacturing capability |
|---|---|---|
| FAST GROWING MARKET SEGMENTS | | |
| *Surface mining* | | |
| Rotary blast hole drills | 1.8 | Nil |
| Crawling draglines | 1.9 | Structural components only |
| Power shovel, 10 yd and over | 1.5 | Very low |
| Loaders, 7.5 yd and over | 2.0 | Very low |
| Off-highway trucks, 120 tonnes and over | 1.3 | Mainly structural components |
| Bulk conveyors | 1.3 | High |
| *Underground mining* | | |
| Drill jumbos | 1.1 | High (but dependent on foreign licences) |
| Trackless mobile equipment | 1.1 | High (but dependent on foreign licences) |
| Underground conveyors | 1.3 | High |
| *Mineral beneficiation equipment* | | |
| Classifiers (cyclones) | 1.4 | Low |
| Flotation cells | 1.5 | Dependent on foreign licences |
| Centrifugal dryers | 2.0 | Low |
| RELATIVELY LOW GROWTH AREAS* | | |
| *Surface mining* | | |
| Power shovels under 10 yd | Negative growth | Low |
| Loaders smaller than 7.5 yd | Negative growth | Low |
| *Underground mining* | | |
| Hand and post drills | 0.8 | High (world product mandate) |
| Rail locomotives and cars | 0.2 | High |
| Mine elevators, skips and hoists | 0.7 | High |
| Ventilation equipment | 0.5 | High |
| *Beneficiation equipment* | | |
| Screening equipment | 0.2 | High |
| Crushing equipment | 0.5 | High |
| Grinding equipment | 0.2 | High |
| Thermal dryers | 0.1 | High |
| Portable mineral plant | 0.6 | High |

SOURCE: Based on Frost & Sullivan, New York.

* Fraction of the average growth rate.

capability to produce these items is either very limited or depends on foreign firms for the supply of key components and technology. On the other hand, unfortunately, Canada has a manufacturing capability in almost all categories for which a relatively low growth is forecast over the 1980s.

**Table 7. Specific opportunities for the Canadian mining equipment manufacturers**

TYPE A (SPECIALIZED MINING EQUIPMENT)

1. *Open-pit mining equipment that has relatively low unit prices*
   —Rotary blast hole drills
   —Front-wheel loaders over 7.5 yd
   —Off-highway trucks, 120 tonnes and over (engines and drive trains)
2. *Underground mining equipment: hard rock*
   —Automated roof bolting, scaling machines, ANFO loaders etc.
   —Hydraulic drilling equipment and continuous mining equipment
   —Continuous loader/hauler
   —Safety equipment
3. *Beneficiation*
   —Classifiers (cyclones)
   —Flotation equipment
   —Centrifugal dryers
   —Filters/environmental
4. *Smelting-refining*
   —Process furnaces
   —Electro winning equipment etc.

TYPE B (GENERAL PURPOSE EQUIPMENT)

1. *Bulk material handling equipment*
2. *Pumps, compressors—high capacity*

TYPE C (LOW-TECHNOLOGY, BULKY ITEMS)

—Metal fabrication—tanks, bins, pipes
—Parts—bulldozer attachments etc.
—Custom casting etc. . . .

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

Unless a clear reorientation of corporate strategies and manufacturing product mix is implemented, the Canadian mining machinery sector will have significant difficulties in meeting the future requirements of the domestic mining industry. This probably will mean further reductions in the domestic content of capital goods used in Canadian mineral resource projects.

## Policy Options — Low-Technology Sector

The low-technology sector of the mining equipment industry has a fair degree of Canadian content and has historically shown a satisfactory ability to adjust to new challenges and opportunities. The demand for the output of this industry is cyclical, but the long-term trend is favourable. The Canadian dollar devaluation has given a 15 per cent protection against competing imports, and rising fuel costs have enhanced its transportation advantage over foreign competition. This is clearly a sector that would be reasonably amenable to the recently announced industrial benefits initiatives of the federal government.[1]

However, such measures could be largely ineffective if the skilled labour situation is not properly addressed. Low-technology custom fabricators tend to locate their plants near the mine site in order to cut transportation costs, and could be vulnerable to a chronic shortage of skilled machinists and construction workers. This might well be the case in the western

[1] Industrial Benefits Initiatives announced by the Department of Industry, Trade and Commerce, Ottawa, August 27, 1981.

provinces where current labour shortages will be further aggravated by the development of energy megaprojects. The problem arises when large pools of unemployed skilled workers in other parts of the country are underutilized because of interoccupational-interprovincial barriers to labour mobility. A strong effort must be made to ensure that labour mobility is not impaired by unduly stringent regulations by the skilled trades or by provinces. This effort can be complemented by the extension and more efficient use of existing manpower training-apprenticeship programs.

## Policy Options — High-Technology Sector

Canada's specialized mining equipment industry is truncated. Compared to the low-technology custom fabrication industry, this sector is far less amenable to traditional policy directions, which focus primarily on ways to stimulate purchases from Canadian sources. In contrast, a battery of additional initiatives is needed for the specialized minerals equipment industry, if Canada is to capture the "backward-linked" industrial opportunities from the mineral megaprojects of the 1980s, including those in the tar sands. These initiatives would be aimed at industry structure and performance.

### Procurement Policy and Strategic Planning

One important policy thrust, also emphasized in the industrial benefits initiatives, relates to procurement policy and strategic planning.

Canadian procurement in all existing and new mine-mill-smelter-refinery operations can be promoted by improving communication between the mining industry and the equipment industry, small Canadian mining equipment enterprises in particular. This can be done by establishing strategic priorities to create and maintain a continuous flow of information between the mining industry and Canadian equipment manufacturers. Such a flow would include, in one direction, the mineral industry's basic requirements and technological trends, and in the other direction, a compilation of Canadian manufacturing capabilities by region, including information on the Canadian content of goods.

To be effective, the various input requirements and future technological trends of Canada's major energy and mineral projects have to be analyzed, and those requirements related to the country's supply capabilities and their expected growth. It should then be possible to identify potential supply bottlenecks that could delay projects and increase capital equipment costs. At the same time, specific capital goods could be designated as representing strategic industrial development opportunities. To qualify as such, items would have to (a) possess high demand growth and export potential, (b) represent a high-technology area developed in Canadian resource projects and where Canadians have the potential to acquire a leading international role, and (c) reflect currently low Canadian supply capability. In relation to the above initiatives, a strategic industrial opportunity program can be established within the context of government's current industrial benefits activities. Such a program could also include an assessment of those factors now forestalling the expansion of Canadian capacity and capability to the desired extent, and the development of the most appropriate government counteractive strategy.

The new Industrial Opportunities Program (IOP), announced by the Honourable A.J. MacEachen in his November 1981 document, *Economic Development for Canada in the 1980s*, and the Office of Industrial and Regional Benefits (OIRB) are appropriate focal points for most of the analysis required for the industrial benefits initiatives. A government-wide effort is required, given the scope and complexity of possible interaction between industrial

development policies and future technological trends, capital cost escalation, mining industry competitiveness, oil reference pricing, etc. that involve other strategic issues and public policy goals.

Tar sands and heavy oil recovery, Arctic and ocean industries, copper, zinc and nickel hydrometallurgy and pyrometallurgy are examples of areas where substantial market opportunities exist and where Canadians could rapidly move to the leading edge of technology. Other significant candidates are certain types of surface mining equipment — rotary blasthole drills, large front-end loaders — underground hydraulic drilling equipment, electrically driven underground trackless equipment and continuous mining equipment. Development of advanced Canadian capability in all these areas could significantly enhance the competitiveness of the domestic mining industry, as well as provide significant new job opportunities in research, development and manufacturing.

Supply bottlenecks would be reduced and strategic industrial opportunities greatly enhanced, if major mining and other resource projects could be scheduled so as to minimize the bunching of demand for equipment that is in relatively short supply.

Procurement from Canadian sources is desirable where feasible without prejudice to the mining industry's competitiveness.

Finally, "buy provincial" legislation has been implemented in some provinces. Such practices, if generalized and not complementary at the national level, could lead to further balkanization of Canadian industry, and of the Canadian mining machinery sector in particular, so reducing the efficiency gains that could be expected from the existence of a substantial domestic market base.

On the other hand, an integrated federal-provincial approach to procurement policy, by fostering the development of world-scale manufacturing operations, would enhance the industry's competitiveness on world markets. The existence of a pool of national resource projects, whose development could be coordinated by the federal government and the provinces, offers the additional advantage of providing alternatives or solutions that might be impractical on a project-by-project basis. For instance, a series of sequential projects might well justify the establishment of highly technical, specialized joint ventures, with possible government support.

## Product Mandating

One method of dealing with the truncation arising from the branch-plant structure of the mining equipment industry is to encourage large international firms to grant *product mandates* to their Canadian subsidiaries in those areas identified in the preceding section as representing strategic industrial opportunities. Product mandates generally cover (a) product development (R&D and design), (b) production for world markets, and (c) international marketing. Therefore, a product mandate can generate economies of scale, improve Canadian competitiveness, increase Canadian production, and build R&D engineering and design capability in Canada. But ultimate control still rests with the parent company outside Canada — the Canadian affiliate remains highly vulnerable to headquarters decision-making in innovation, allocation of product lines and international marketing.

As far as EMR is concerned, CANMET participates with the private sector in technological research and development. This CANMET participation can be used as a lever for increased Canadian fabrication and marketing mandates. It would also ensure that Canada gains and retains full control of the technology developed in Canadian mines and other resource projects such as tar sands plants.

### Broadening Product Coverage

A variety of positive actions could be taken to induce a more active approach by the manufacturing sector towards new opportunities. Discriminatory measures against foreign firms, or foreign owned firms operating in Canada, are undesirable. However, inducements could be provided to mining companies to integrate into the equipment industry. In addition or alternatively, special "infant industry" types of assistance or fiscal inducements of a temporary and transitional character could be made available to help promising mining equipment enterprises expand into new product lines.

Each option has its attractions and drawbacks, and each may be more appropriate in certain situations than in others — a careful examination of these policy alternatives is necessary.

### Research and Development Support and Financing

R&D expertise based on government in-house activities (CANMET, National Research Council, etc.), as well as government R&D funding, can be used more effectively than in the past to establish a joint government-industry technology base that would stimulate expansion of Canadian mining equipment production for both the domestic and export markets. Since government participation would reduce the financial risk associated with mining equipment R&D, such a program should also aim at attracting the participation of the mining sector. The incentive lies in the possibility of reducing unit cost of procurement for the participating firm.

Areas of mineral technology research that offer very significant potential to the Canadian manufacturing industry are those related to (a) energy efficiency, (b) labour efficiency, (c) health and safety issues, and (d) quality of the environment. The Canadian mining industry should be particularly interested in the development of underground automation, continuous mining techniques in a hard-rock environment, new hydraulic drilling equipment, new ground control techniques, wet beneficiation technology (new reagents), hydrometallurgy, sophisticated metallurgical process controls and new safety equipment. Canadian supply capabilities are currently limited in these promising areas and would greatly benefit from any R&D thrust.

### Establishment of a Comprehensive Engineering-Procurement-Construction (EPC) and Manufacturing Capability: The "Consortium"

Canada has developed a significant EPC capability in some mineral resource areas — underground mining, open-cast porphyry copper mining and milling, metallic ore beneficiation, zinc plants — where a strong and consistent domestic demand exists. However, the complementary manufacturing expertise has often failed to match this degree of sophistication and specialization. As a result, Canadian EPC firms usually have found it convenient or necessary to team with more "reliable" foreign manufacturing partners — more diversified, stable and experienced companies with a "trade name".

Canada also has been unable to exploit some of the most significant recent engineering and design achievements developed on Canadian resource projects or by Canadian mining firms. For example, the production license for the top-blown rotary converter (TBRC) copper smelting technology, developed by Inco, has been awarded to Dravo Corp. of the United States. Project management at tar sands plants also has been awarded to foreign engineering firms.

A major initiative is needed if Canada is to develop a minerals equipment industry that can produce and install integrated mine-mill-smelter-refinery facilities for domestic and international markets. This could be achieved by fostering the establishment of Canadian consortia of engineering and construction contractors, mining equipment manufacturers and perhaps some mining firms. The aim would be to achieve compatibility of equipment design and jointly

market an integrated mine-mill-smelter-refinery. Measures also can be taken to increase the ability of Canadian EPC firms to manage the largest projects in areas offering exceptional market possibilities, e.g. tar sands and heavy oil technologies.

### Export Promotion

If Canada is to compete effectively in some major lines of production, broader international markets must be penetrated so that volume of production can be increased and unit costs lowered. A total of 14 government programs to promote sale of Canadian manufactured products in other countries already exist. Those most relevant to mining equipment are the Office of Overseas Projects, the Export Development Corporation (EDC), the Canadian Commercial Corporation (CCC), the Promotional Projects Program (PPP), and the Program for Export Market Development (PEMD).

Ironically, there may be too many export promotion programs in proportion to the volume of export business that can be generated in the mineral equipment sector — much of the sector comprises branches of foreign firms that do not have the mandate or the capability to seek export business. Also, a small innovative Canadian firm might be aware of export opportunities but may be unable to exploit them because of a lack of suitable Canadian manufacturing partners to complement its own area of expertise. Alternatively, small or medium firms may be deterred from participating in government export promotion programs because the procedures leading to a satisfactory deal are too complex and time-consuming.

Clearly, there is no need to reinvent the wheel by duplicating existing export promotion programs. The task, rather, is to adjust the system now in place and perhaps augment it with complementary instruments so it meets the specific promotion needs of the mineral machinery sector.

The effectiveness of existing programs would be enhanced if two policy measures already proposed were implemented — the requirement that Canadian subsidiaries of foreign companies be granted product mandates, and the establishment of Canadian consortia with comprehensive engineering, construction and manufacturing capability.

To be fully competitive on the world market, however, a consortium would have to integrate a top-qualified team of experts in mineral technology, administration and finance — a group capable of directing every phase of a mining project from initial prospecting to production, management and sales. This might require the participation of leading Canadian mining firms and integration of some of the existing export promotion programs, as well as the development of some complementary measures. For example, on the technological side, it might be desirable for government agencies such as CANMET to participate in the consortium to the extent that they would become more involved in strategic R&D programs along with the private sector.

There is a need for an "action plan" for the mining machinery and equipment sector that would target existing public programs in support of concrete actions on the part of the private sector. In particular, a comprehensive marketing plan for Canadian mining and technology, oriented towards capturing future opportunities in both the domestic and international markets, will be prepared as part of the machinery strategy of the Department of Industry, Trade and Commerce.

# Mineral Science and Technology

## Introduction

Scientific and technological activities in the mineral sector are undertaken to increase the fund of knowledge about the country's mineral resource base, and to develop more efficient ways of extracting minerals from the ground and processing them into useful products. These efforts also include the development of techniques and equipment to improve the health and safety of workers and to minimize harmful effects on the environment. The provision of an adequate level of scientific and technological activity is therefore central to the federal goal of achieving the highest possible quality of economic development and social benefit from Canada's mineral resource base.

Government is involved with industry at all stages of mineral science and technology (S&T), although the emphasis is not uniform throughout the system — traditionally, government has been more active at the geoscience stage than the production or consumption stages. Nevertheless, government S&T activity touches the entire mineral system.

Federal and provincial geological surveys carry out geological mapping, investigate and document the distribution and characteristics of mineral deposits, conduct land-use and terrain studies, do offshore geoscientific studies, and develop exploration techniques and equipment. CANMET conducts fundamental and applied research on mining and processing technologies, properties of materials, metals fabrication and work related to mineral and energy management, environmental impact, and worker health and safety.

In the provinces, complementary work is carried out by various government-supported research institutes such as the British Columbia Research Council, the Alberta Research Council, the Saskatchewan Research Council, the Ontario Research Foundation, Le Centre de recherche minérale du Québec, the New Brunswick Research and Productivity Council and the Nova Scotia Research Foundation.

Industry research and development has been concerned mostly with technological applications in the various sectors of the mineral industry. In exploration, Canadian industry has developed advanced airborne geophysical systems, ground geophysical equipment for the mining industry and pioneer methods of geochemical exploration.

Canadian universities have traditionally emphasized basic research, without specific application to a particular industrial field or process. However, a recent trend has been toward increased industry- or process-specific research allied to the practical applications of mineral science and technology.

## Principal Needs for New Mineral S&T

The encouragement of mineral science and technology at the federal level has contributed in no small measure to the growth of Canada's mineral industry. Canada's competitive edge in technology has offset, to a degree, the industry's disadvantage in terms of higher wage costs and lower ore grades when compared to other mineral exporting countries. To remain competitive, however, Canada must remain at the forefront of newly developing technology, and must ensure that this new technology is continuously adopted by the mineral industry.

## The Canada Centre for Mineral and Energy Technology (CANMET)

CANMET, a research organization within the Department of Energy, Mines and Resources, is engaged in a wide range of studies that focus on the safer and more efficient extraction, processing and use of the country's mineral resources. Founded in 1907 as the federal Mines Branch, it was reorganized and renamed in 1974 to more accurately reflect a much broader scope of activity in the fields of energy, mining and minerals.

The work at CANMET includes basic and applied research, development, demonstration and, finally, technology transfer. This work is not carried out in isolation — close links are maintained with industry and with other research organizations to ensure that all projects are undertaken in response to, or in anticipation of, real needs and problems.

CANMET's problem-solving lies in two distinct but related fields — minerals technology and energy technology. The staff consists of about 700 scientists, engineers, technicians and other support staff, and the current operating budget is about $33 million. These resources are divided fairly evenly between the two areas of work, with 368 persons and $15 million devoted to minerals research, and 336 individuals and $18 million working in energy research. Currently, about $6 million of the yearly budget goes into contracts for R&D projects conducted by private industry and universities.

In minerals technology, CANMET's work falls into three categories — mining, processing and utilization. This reflects the fact that the research program is relevant to the full range of mineral resource activity in Canada, starting with research down in the mine and going all the way through ore processing to research on the fabrication of finished metallic products. The activities briefly described here represent only a few highlights of this extensive program.

Current thrusts in CANMET's mining research are aimed at helping industry mine deeper orebodies economically and safely. This work includes the development of new methods to detect fractures in mine roofs — roof collapse is one of the great hazards in mining — as well as studies on the overall regional stress conditions that affect mine stability, particularly where the workings of several different companies must be considered. Research to improve health in the mine workplace is centred on the reduction of dust, fumes and radiation. This work includes the development of instruments to effectively monitor these hazards. Regarding the problem of fumes from diesel-powered equipment in the mine, CANMET has developed, to the demonstration stage, technology to reduce diesel exhaust emissions by 70 per cent.

In the area of mineral processing, CANMET is working to develop new and improved methods of extracting minerals from ores — methods that also will be more energy-efficient and have minimal impact on the environment. These efforts include studies on ways to improve extraction and processing techniques for the valuable but complex and difficult sulphide ores found in New Brunswick, and the development of processing methods that will reduce sulphur dioxide emissions and toxic wastes that result from mineral processing.

A major objective of CANMET's utilization research is to improve the physical properties of materials derived from minerals. The goals are greater durability, improved structural integrity and better performance of such materials. In one area of this work, studies are under way to reduce corrosion of steel in various environments, particularly in the ground and in salt water, by developing new alloys and more effective protective measures. CANMET is also working on a casting technique that will improve the abrasion resistance of mining and processing equipment that is subject to severe wear.

Failure in metal structures often occurs at or near welds; CANMET is working on techniques to predict stresses and distortions in welded structures that could lead to cracking. Another major program of utilization research is directed at problems encountered in metal processsing. This includes work on casting methods, the development of harder and longer-wearing rail steel, as well as materials for ship plate and propellers that will be tough enough to stand up to Arctic use.

There are six broad areas in which new or refocused S&T efforts are needed to improve the position of the Canadian mineral industry. These areas require S&T activity, regardless of whether it is conducted by the private or public sector, to enhance the quality of mineral development in Canada.

## The Nature and Geological Environments of Mineral Resources

The discovery of new mineral deposits in Canada has become progressively more costly and difficult, as the relatively easy-to-find orebodies are located and mined out. If the mineral industry is to remain competitive, the new sources of ore that exist in Canada must be found by explor-

ing more deeply into the ground, and by extending the search into the more inaccessible regions of the country. This means that a continued effort must be maintained in the geosciences so that more accurate and complete data on the Canadian landmass can be assembled — greater knowledge about the distribution, characteristics and geology of mineral deposits and the rocks that contain them.

Fundamental studies of the regional characteristics and settings of mineral deposits for the entire country are conducted by a skeleton staff at the Geological Survey of Canada (GSC). This is an area where a significant payoff from increased effort could be expected. Also, the development of better ways to integrate and display geoscience data on maps would improve mineral exploration and resource assessment efforts. The returns would likely be substantial if integrated resource survey programs — geological, geophysical and geochemical mapping — were introduced to provide systematic information and interpretation of specific areas, particularly in northern and Arctic regions.

There is a particular need for more accurate methods of resource assessment on Canada Lands, for resource management purposes — systems that can provide accurate inventories of

## The Geological Survey of Canada

The Geological Survey of Canada, one of the nation's oldest scientific services, has been accumulating and publishing information on the Canadian landmass since 1842. It is one of the major scientific branches of the Department of Energy, Mines and Resources.

The Survey's objectives are to provide a comprehensive inventory and understanding of the country's geological framework and related processes. This information is fundamental to all mineral exploration, assessment and development, and is used by the government to formulate policies for the rational use of Canada's mineral resources. In 1981, the budget was approximately $35 million, and the Survey had about 750 employees, of whom half were scientists.

In meeting its objectives the Survey places special emphasis on:

- Ascertaining Canada's energy and mineral resources;
- Identifying and describing geological features and processes that affect the environmental and ecological equilibrium,
- Identifying and assessing natural hazards; and
- Disseminating information obtained from scientific studies and geological mapping programs of Canada's landmass and continental shelves for use by other government agencies, industry and the general public.

To carry out its tasks, the GSC is organized into nine divisions, six of which are in Ottawa:

The *Cordilleran Geology Division*, with offices in Vancouver and at Patricia Bay on Vancouver Island, studies all aspects of the geological framework of the Canadian Cordillera and the Pacific Continental Shelf.

The *Institute of Sedimentary and Petroleum Geology* in Calgary provides comprehensive information on the geology of the western and Arctic sedimentary basins, and assesses Canada's fossil-fuel resources.

The *Precambrian Geology Division* studies all aspects of the Precambrian geology of the Canadian Shield, including its framework, history, resources and the processes responsible for its evolution.

The *Atlantic Geoscience Centre* in Dartmouth, Nova Scotia carries out geological and geophysical studies of the Atlantic and Arctic offshore regions and sedimentary basins of the Appalachian region, to determine the geology, resources and processes at work in the evolution of these areas.

The *Resource Geophysics and Geochemistry Division* develops and demonstrates technology for use in the acquisition, analysis and interpretation of geophysical and geochemical data, and applies this technology in surveys of the Canadian landmass.

The *Economic Geology Division* integrates regional geology with mineral deposit data and metallogenic concepts to determine the probable distribution and potential abundance of Canada's non-hydrocarbon mineral resources.

The *Terrain Sciences Division* provides comprehensive geological information on the surficial materials, geomorphic processes and natural terrain hazards of the Canadian landmass, and on the capability of the terrain to support human activity.

The *Central Laboratories and Technical Services Division* provides analytical services and mineralogical expertise required by other divisions of the GSC.

The *Geological Information Division* communicates the results of the GSC's scientific program to industry, other government agencies and the general public, mostly in the form of maps and reports.

known resources and reasonable estimates of the amounts, kinds and probable distribution of resources not yet discovered. Alienation of lands, for whatever reasons — national parks and wilderness reserves, ecological preserves, native land-claim settlements, environmental sensitivity, waste disposal sites, etc. — will require judgments about the present and future social values of the lands in question. Sophisticated methods for making such judgments are not in place, although initial progress has been made within EMR, DINA and some provincial agencies.

## Exploration Technology

The need to locate new mineral deposits at greater depths means that advanced technologies capable of "seeing" deeper into rocks and beneath cover materials must be developed. Remote sensing technologies have been in use for many years, but most first-generation systems have reached, or are near, their limits of penetration, generally less than 100 metres. The new systems that are needed will evolve, in part, from existing technologies — airborne, ground-portable and downhole electrical, electromagnetic, magneto-telluric, magnetic, gravimetric and seismic instruments. An important auxiliary need is the development of accurate, self-contained position-tracking systems for aircraft, ships and people; these can be evolved from existing military and space instrumentation. Other needs include portable analytical instruments for determining, in the field, element concentrations in rocks and surface materials, and systems for remote processing and display of data collected during field surveys.

Canada has established an internationally recognized standard of excellence in exploration technology development. Since the early 1970s, about 75 per cent of the world's mining geophysical equipment has been of Canadian manufacture. About 85 per cent of the world's airborne magnetic and electromagnetic surveying has been conducted by Canadian firms over the past decade or so. The GSC, in cooperation with Canadian geophysical contractors, has developed a number of world-class technologies in this area, including (a) new methods for systematic high-resolution aeromagnetic surveys, (b) an advanced airborne radiometric survey system ("Skyvan"), (c) the airborne gradiometer (vertical magnetic gradient system) — a technique that is proving remarkably successful in interpreting bedrock geology beneath surface cover materials, (d) new methods in geochemical survey technology, and (e) the Trace Atmospheric Gas Analyzer (TAGA). Developed in cooperation with the Institute of Aerospace Studies at the University of Toronto, TAGA demonstrates the "unprogrammed benefits" side of R&D. Conceived as an exploration tool, it played a key role in identifying the serious chemical waste problem at Love Canal, and it was used following the Mississauga train derailment for on-site monitoring of chlorine gas levels.

Each of the above technologies required about 10 years to develop, from basic R&D through hardware and software acquisition, testing and modification and finally, demonstration. The demonstration phase was critical, since the mining and exploration industries are reluctant to adopt new technologies until their usefulness is proved through extensive demonstration under a variety of field conditions.

Although domestically and internationally successful, the Canadian diamond drilling industry does not perform R&D; returns are uncertain, and firms are small. In fact, R&D on drilling technologies and methods is almost nonexistent throughout the world. With radically new technologies on the horizon — lasers, ultrasonic techniques — and the growing availability of sophisticated slimline down-hole measuring, logging and sensing tools, there are significant opportunities for Canadian R&D in this field. One trend likely to evolve is "wildcat" drilling to gain subsurface geological information and for positioning downhole geophysical and analytical instruments — e.g. for continuous, in situ major and minor element analysis. This is ancillary to traditional reasons for drilling. The application of such concepts requires fast, portable and

cost-efficient drilling techniques and equipment. Currently, the federal government is not engaged in drilling R&D, but exploration technology development is needed in this country to discover deeper-seated mineral deposits. Drilling accounts for more than half the total exploration expenditures in Canada; the cost reductions resulting from an R&D effort would be substantial.

## Mining Technology

Canadian mining technologies had to be world class in underground mining to cope with typically difficult ground conditions encountered in the Precambrian Shield areas. Federal R&D, chiefly by CANMET, has actively contributed to advances in mining techniques. A notable example is CANMET's Pit Slope Stability program, which has developed guidelines and engineering handbooks for Canadian industry on the prevention and control of slope stability problems in open-pit mines, mainly in the Cordillera Region of western Canada.

Areas of current R&D need in Canadian mining technology include:

- Rock stability to control rock falls, including the development of automatic systems for monitoring rock stresses;
- Ventilation systems to reduce underground health hazards, particularly in undersea coal mining in Cape Breton;
- Methods and systems to continuously monitor natural gases (methane, radon) and man-induced pollutants (dust, diesel exhaust gases) in mines;
- Improved and more energy-efficient methods and systems for blasting, rock hauling and rock cutting;
- Methods to improve extraction ratios through better and safer mining procedures; and
- Improved, more reliable underground communication systems.

## Mineral Processing and Fabrication Technology

Development of mineral processing and fabrication technology in Canada has followed patterns similar to mining technologies. World-class processing innovations have been made by Canadian firms, particularly in major commodity areas dominated by a small number of large corporations. Notable are nickel processing technologies pioneered by Inco and Sherritt-Gordon Mines, copper-zinc extraction processes developed by Noranda, and modern cost and energy-efficient techniques introduced by the Canadian steel and aluminum industries.

Federal R&D in processing and fabrication has concentrated on areas that benefit smaller, independent Canadian firms. This emphasis is necessary because technology developed by larger firms may be retained exclusively for their own use. CANMET has for decades provided a valuable custom ore-beneficiation and metallurgical testing service for Canadian developers of mineral deposits. Much current R&D effort at CANMET is aimed at methods to improve efficiencies in materials and energy savings in practices employed in the Canadian metals fabrication industry.

Canada is running out of the low-cost, high-quality deposits on which the mineral industry has long depended. Such deposits may still be found, but on average, the orebodies that come on stream in future will be of lower grade or will present metallurgical problems. Individual companies may be unwilling to undertake the required research on milling, concentrating and smelter technologies in view of the risks involved. Nevertheless, many companies would benefit from government technological breakthroughs.

In processing — grinding, concentrating, smelting and refining — R&D is needed to:

- Reduce energy requirements in cement and aluminum production, the two most energy-intensive operations in the mineral industry;

- Reduce energy requirements for crushing and grinding in producing base metal concentrates;
- Reduce pollutants from the roasting of base-metal sulphides by improved treatment of gaseous byproducts (sulphur dioxide) or through new replacement technologies;
- Develop in situ and biological leaching processes as alternate extractive processes;
- Develop economic processes for the recovery of vanadium and zirconium from oil-sand wastes; and
- Develop economic processes to produce strategic minerals such as chromium and manganese from economically marginal Canadian deposits (see *Security of Supply*).

Major savings in materials and energy can be made in fabrication operations through improvements in conservation practices, recycling efficiencies, component design and substitution methods. R&D priorities here include:

- Energy and materials conservation through better metal melting processes and near-final shape forming processes, e.g. casting;
- Component design and selective substitution of materials that make end products more amenable to recycling;
- Development and refinement of processes to improve the qualities of metals and alloys — strength, corrosion resistance, abrasion resistance; and
- Improvements in working and finishing processes, e.g. casting, forging, joining of light-weight, high-strength metals and specialty alloys, many of which have applications in high-technology industries.

## Health and Safety and Environmental S&T

R&D aimed at social and environmental concerns relates to all stages of the mineral sector, from exploration to fabrication. The reduction of deleterious industrial effects on the environment starts with a determination of "natural state" conditions, including inherent hazards unconnected with man's activities — harmful elements in waters and soils, potential earthquake zones, landslide risk, etc. Monitoring procedures then isolate superimposed man-induced hazards, such as acid rain and industrial wastes. Also, environmental R&D is applied in the planning and engineering of such structures as mines and waste disposal plants in order to maximize the containment and neutralization of hazardous substances. In the area of workplace health and safety there is a wide range of R&D efforts — dust, gas and exhaust control in mines and processing plants, rockfall monitoring and preventive procedures in mines, ventilation, automatic shutdown systems, robots, remote workface monitoring and inspection systems, protective clothing design, and a variety of other measures. Areas that need particular emphasis include:

- Accelerated research on surface and subsurface geological characteristics and hydrogeological processes of sedimentary basins, on which the bulk of Canada's population lives, and on which most land-use activities occur. Many of the major problems of disposal, storage and neutralization of man-induced wastes and pollutants, including acid rain, will be solved by such research;
- Research on the special geologic, geomorphic and hydromorphic conditions of frontier environments — North, Arctic, continental shelves and oceans — in the context of special requirements for structures, industrial operations and other human activities;
- Development and application of an array of automated measuring, monitoring, recording and inspection systems to provide early warning of rockfalls and rock instability hazards, and for dust, methane, radon, exhaust-gas and radiation detection and air-purity control in mines; and

- Development of methods to expand the use of automated control systems and remote-controlled machinery and robots in hazardous operations and environments in mines, mills and smelters.

### Security and Strategic Considerations

A range of options to cope with potential supply disruptions of certain key imported minerals is discussed in the *Security of Supply* chapter of this paper. One role for S&T is to assemble information on the potential for supplying these commodities from domestic sources — possible unrecognized geological environments that might contain deposits of these strategic minerals. Examples in this context are EMR's current re-investigation of economically marginal deposits and geological environments of chromite in Canada, and the recent identification by the Geological Survey of possible phosphate rock environments in the Yukon.[1]

Other potentially productive avenues of R&D are investigations by CANMET into new methods of treating known low-grade domestic ores — e.g. chromite from deposits in Manitoba – to improve the viability of such deposits. Also, federal government agencies and industry could possibly cooperate with other Western importing nations in studies to identify potential sources of supply for strategic commodities outside Canada. Such programs obviously would require bilateral or multilateral agreements as instruments of cooperation.

## Constraints to Adequate Mineral S&T

In determining federal options that should be pursued to ensure adequate mineral S&T in Canada in light of the needs that have been identified, three particular impediments in the mineral system must be considered. These relate to proprietary information — particularly information on the resource – within the mineral industry, lack of innovation in some aspects of the mineral system in spite of being a world leader in others, and fragmentation of federal efforts to promote S&T.

### Proprietary Knowledge

Mineral S&T development is affected by the degree to which industry technologies and mineral resource information are owned by individual corporations, both Canadian and foreign. While this may not have been a significant problem in the past, the situation is changing rapidly. There is increasing concentration of such information in the exploration segment of the industry through the incursion of large, multinational energy firms and foreign based multinational mineral corporations, some of whom have visible or invisible ties with home-state governments. Most of this activity has centred on uranium, but recently such firms have been moving into other commodity areas as well. The concentration of "ownership" of technical knowledge, especially if it resides in foreign controlled corporations, can impede development and exploitation of Canada's mineral resources.

### Lack of Innovation

Lack of innovation in the mineral sector is especially apparent in the mining equipment industry. In the mineral system itself — exploration drilling, mining, concentrating, smelting, refining, fabrication — no definitive study has been done to indicate whether or not parts of this sector are using technology to the highest potential. Some argue that the Canadian industry is a

[1] Although not a strategic commodity in the context discussed here, all of Canada's phosphate requirements, mainly for the fertilizer industry, are currently imported from the United States.

world leader in technology, while others claim that lack of technological innovation causes the industry to operate below potential. To the extent that the latter is true, a more dynamic government role in technological leadership is suggested.

A 1976 study[1] concluded that mining firms face major difficulties in introducing new process technology, due in some degree to the deficiencies in the mining equipment industry in Canada. Also, smaller mining companies are worse off than larger companies that have a greater S&T capability, either in Canada or through access to a foreign parent company. The Canadian industry tends to be isolated and is not exposed to the day-to-day opportunities for innovation that would occur if a dynamic mineral equipment industry were in close proximity. In foreign countries, on the other hand, such close association does benefit the mineral industry. Examples include: Outokumpu in Finland; the U.K. Association of British Mining Equipment Companies (ABMEC) which works, for instance, in close relationship with the National Coal Board so that the cross-fertilization of ideas and exchange of experience between equipment maker and user produce a constant succession of innovations and improvements; Sytramines in France; and Fachgemeinschaft Bergwerksmaschinen in West Germany.[2]

An Economic Council of Canada study[3] shows that over the 1960s and 1970s, in a small segment of the mineral industry — nonferrous smelting and refining — most expenditures on innovations were in the manufacturing start-up stage. This stage accounted for two thirds of applied R&D expenditures, with the remaining one third going into basic research, applied research and development. The heavy emphasis on start-up reflects the lack of importance attached by Canadian industry to basic and applied research. With the private sector emphasis on start-up, are opportunities being missed in applied research? This may be so, in view of the apparently very conservative behaviour in innovation. For instance, the Economic Council of Canada study shows that the average Canadian innovation was launched 12 years after it had been introduced elsewhere in the world. This suggests an industry that has been cautious in introducing techniques — that insists on being fairly certain of their economic feasibility before introducing them. On the other hand, the Canadian mineral industry is very advanced in some areas; waiting until new techniques are perfected may be a sound strategy that ensures a rapid payback. The smelting and refining industry, in fact, achieved a very short three-year payback on 90 per cent of its innovations during the 1961-79 period.

### Fragmentation of Effort

One problem in implementing programs to encourage innovation and development of mineral science and technology is the lack of a clear focal point for federal support. There are a large number of federal departments that are involved, directly or indirectly, in mineral S&T funding. This is not necessarily inefficient, but there is a need for better liaison and coordination among the various participants. The development of exploration and mining technologies, and their manufacture and marketing for both domestic and export use, clearly presents an opportunity that has not been fully grasped in the past. The establishment of a federal focal point to coordinate R&D in mineral-related technologies could be considered as a possible means of pursuing such objectives.

## OPTIONS

To ensure an adequate level of mineral-oriented scientific and technological activity in Canada, so that the country's mineral industry can remain competitive and thus contribute its full

[1] Richardson et al., *The Role of Innovation in the Mining and Mining Supply Industries* (MRI 146.EMR, 1976).
[2] Mining Magazine, June 1981.
[3] Economic Council of Canada Preliminary Report: *Innovation and Technological Change in Five Canadian Industries* (Discussion Paper, Dennis P. de Melto, Kathryn E. McMullen and Russel M. Wills, October 1980).

potential towards Canada's per capita income, the following federal initiatives are suggested for consideration, based on the areas of need that have been identified.

## Earth Sciences Initiatives

*Mineral Deposit Research and Modelling.* Although government, industry and university scientists study mineral deposits, the total level of R&D effort is inadequate. In addition, effort is fragmented by increasing requirements for assessing the mineral resource potential of specific parts of Canada. Consequently, the country-wide study of mineral deposits to understand how they originated and evolved is now at a low level. This has been recognized by the chairmen of university geology departments, the Geologists Subcommittee of the Provincial Mines Ministers, the Canadian Geoscience Council and the National Geological Surveys Committee. At present, the Canadian Geoscience Council is searching for the most effective mechanism for Canada to re-establish its necessary capability in this area. The output from such research should provide the basis for more intelligent strategies for mineral exploration and improved methodologies for mineral resource assessment. Accordingly, the Canadian Geoscience Council should be urged to proceed with its study as quickly as possible, and to ensure appropriate representation from industry, universities, and federal and provincial agencies.

*Exploration Technology Development.* The Federal-Provincial National Geological Surveys Committee has identified exploration technology development as a priority need, because of the high likelihood that most of the easy-to-find, close-to-surface mineral deposits have already been located in Canada. However, it is thought that there are deeper and less accessible mineral deposits that could be mined profitably, especially in northern parts of Canada. Most Canadian expertise on exploration technology resides in the private sector; an appropriate way for government to advance exploration technology, therefore, is to utilize the private sector expertise. Individual effort by companies is not resulting in the progress that could be achieved if companies were to pool their expertise and S&T funds. Government leadership in such an effort, as well as the use of government facilities for industrial research would have a substantial payoff.

*Data Standardization.* The task of accumulating scientific and technological data is a continuing one. Current knowledge should reflect past efforts. Unfortunately, past practices have been unsatisfactory in some areas, as in the case of inadequate standardization and consolidation of existing data in a number of federal and provincial government agencies. Although information is widely available and well indexed, basic data may not be in a form to be readily compared or merged. As a consequence, both government and industry users of data may not be making best use of the results of geoscience investigations. Therefore, federal-provincial-industry efforts should be made to standardize and consolidate national geoscience data, as was done by EMR to establish the CANMINDEX computer file in 1975, in full consultation with provincial agencies, DINA, universities and the industry.

*Geoscience Information Availability.* Although the competitive nature of the mineral industry requires that certain earth science information be kept confidential, much of this is unnecessary. This results in duplication of effort by companies and prevents utilization of data that might prove beneficial to the mineral industry. Regulations requiring release of specified categories of earth science information, and reduced secrecy periods, could assist in this regard. The federal role could be aimed at standardization in all Canadian jurisdictions, through leadership on Canada Lands and negotiation with provincial governments with respect to lands under their jurisdiction.

*Manpower Planning.* There is a current shortage of geologists and geophysicists in Canada that could seriously undermine the overall mineral S&T effort, including the government role. Students are abandoning higher degree programs in large numbers to work in industry, thus jeopardizing the future supply of highly trained manpower. At the moment, a major federal govern-

ment task force is addressing the issues and solutions regarding skilled manpower shortages. Action on the recommendations of this task force, when it completes its work, should be a high priority.

## Minerals Technology Initiatives

*Technology Monitoring.* A technical group should be established to take continuing and systematic inventory of the technological processes in use in the Canadian mineral industry. This survey would focus on selected problem areas and address appropriate individual operations, to identify technological reasons for variation in production costs and profit levels. Looking abroad, the inventory could collect "technological intelligence" to determine whether superior technologies are in use or being developed elsewhere, and whether it would be feasible and desirable to introduce these into the Canadian mineral industry. The industries to be covered are mining equipment manufacture, mining, milling, concentrating, smelting, refining and certain fabrication activity.

*Technology Assessment.* The previous initiative would produce an inventory of all the technologies in use or being developed. Technology assessment would ask whether the Canadian mineral industry and the Canadian mining equipment industry are using the latest and best feasible production techniques. This assessment must give consideration to the business and economic environment as well as technical factors. It is possible that the latest and best technology would be delayed in its introduction due to cash-flow problems, business expectations, age of existing capital stock, to give a few examples only. Technology assessment would also determine why the use of best technology may be lagging in the mineral industry in Canada. These assessments would form the basis for dialogue with industry officials so that industry itself would be encouraged to undertake self-improvement where appropriate. The task of technology assessment is to ascertain whether "knowledge", "methods", "production techniques" or some other factor might be the cause of industry inefficiencies. This step is necessary so that blame for industry weakness is not laid on "technology" if in fact there is another cause. Another important task will be to assess whether or not any lag in innovation or use of technology in the Canadian mineral industry is connected with Canada's lower energy prices — investment plans will have to take account of higher energy prices in the choice of technologies for the future. Furthermore, R&D planning in the public sector should ensure that finances are available for work on new energy-saving technologies of a basic nature in advance of private needs in an energy-intensive mineral industry. Public R&D agencies, particularly CANMET, should be involved in the researching of new fundamental processes that, with further private investment in development, could be engineered to become economical, practical technologies.

*Coordination of Federal Mineral S&T.* The large number of technology transfer and development programs of federal departments should be coordinated and made consistent with government economic priorities. An interdepartmental Coordinating Committee for Minerals, chaired by EMR, could be considered, and a subcommittee on federal mineral S&T could also be established to coordinate federal program initiatives.

*Technology Diffusion and FIRA.* Within Canada, major mineral resource developments are being undertaken by multinational or foreign government backed organizations. Much information flows to these organizations and significant research, often centred outside Canada, is done by them. This reinforces the desirability of strong mechanisms, directed to *all* companies, to ensure the diffusion and application of technology in Canada. The existing FIRA legislation provides a means of technological diffusion in the case of new, foreign mineral investment. Foreign owned companies are being assessed under two existing Principal Factors for Assessment of Significant Benefit to Canada, namely: "Enhanced Technological Development" and "Compatibility with Industrial and Economic Policies".

*More Active Efforts to Develop Appropriate Technology and Improve Use of Information in the Canadian Mineral Industry*. This initiative is a multidimensional effort to address the realities of Canada's emerging mineral economy and to optimize the role of R&D, including that of government, in the pursuit of future economic development.

A strong case is made in this paper that the passive and indirect approach is inadequate in many respects for the mineral industry, and particularly inadequate in the case of the mining equipment industry. Elements of a more active and direct federal role include:

1. *Harmonization of Efforts*. The mineral industry is a traditional economic activity and will remain a fundamental and influential factor in shaping the Canadian economy. Consequently, the integration of federal mineral R&D efforts with other federal government priorities in economic development is a prime goal.
2. *Rationalization of Mineral R&D*. Canada is entering a new stage of mineral development, characterized by more remote mine location and more problematic mining and processing. Mineral R&D efforts therefore must match these new conditions. The situation demands a major thrust, led by EMR laboratories, in R&D related to new basic mining and processing technologies focused on unconventional occurrences of minerals.
3. *Social R&D*. Workers in the mineral industry face conditions that are perhaps the most hazardous found in any industrial sector of Canada. Disease and injury not only cause suffering, but also represent economic losses to individuals, mining companies and society. While industry has an obvious incentive to reduce losses due to disease and injury, the private sector alone does not always have the technical capability to combat these workplace problems. Consequently, there is a clear case for a government R&D effort to open up technical options that can be used voluntarily, or under the weight of regulation, to mitigate the hazards facing workers in the industry.

The federal government is equally concerned with technological developments to limit the adverse effect of industrial activity on the environment. As such activity becomes more intense with continued economic growth, the standards that Canadians have come to expect regarding the quality of their lives will be increasingly difficult to meet — in fact, will not be possible — unless advanced pollution abatement technologies are developed. The situation calls for a new thrust in appropriate R&D by industry as well as government, to permit environmentally harmonious economic development.

4. *Technology Acquisition and Information Dissemination*: This dimension of the initiative is aimed at ensuring that Canadian firms — especially in the mining equipment industry — are in a position, in terms of access to technical knowledge, to realize their full potential for participation in the mineral sector. Three measures are seen as essential:
   - Negotiation with the provincial governments to increase public access to drill-core and other exploration results, in order to foster competition and development;
   - Assessment of the relative benefits of importing select technologies, as opposed to performing the required R&D in Canada; and
   - Creation of a government role as broker for technological information acquired both from its own laboratories and from industrial intelligence activities abroad. Such an activity, undertaken by appropriate units in EMR, would enhance the information flow throughout the industry. Properly organized, it would simply involve more productive and effective use of existing expertise and facilities within EMR.

*Dynamic Federal Role to Raise the Level of Minerals Technology in Canada.*

1. *Demonstration and Pioneer Projects*. Often, one of the limiting steps in the achievement of technological progress is the demonstration phase that bridges the gap between invention and commercialization. Governments, and government technologists, should play an active

role in getting desirable technologies over this demonstration hurdle. The view that an active role for government is required follows from the experience that the soft path of tax incentives and cash grants is often not sufficient to improve the competitiveness of industry through technological progress. The rationale for EMR to play an active role in enabling technologies to surmount the demonstration hurdle is essentially:

- There are very substantial advantages, in an industrial development sense, in being the first to introduce a new technology — both through the direct output of the new facility and, especially, because of the indirect industrial opportunities it creates. Government leadership would yield permanent benefits to the private mineral sector in Canada.
- For a multinational firm there may be no particular benefit in indulging in more R&D from a Canadian base; it may be more practicable to do so from the base in the firm that presumably has the best technical capability, and that is seldom in Canada.
- New technologies are usually of interest to a number of firms in the same business, but they seldom have a mechanism to share the risks and intrinsic high cost of a first plant. As a result each may wait for another to move first. It should be noted that the technical risks — will the process work or work at expected cost? — and economic risks — will product prices and other cost factors behave as expected? — are equally important.

2. *Ownership of Intellectual Property*. Canadian Patents and Development Ltd. (CPDL) is a federal Crown corporation involved in the transfer of technology from government laboratories, contractors and universities to Canadian industry. CPDL is at the moment the subject of an investigation to identify the need for restructuring and refinancing in order to increase its effectiveness in ensuring the commercial application by Canadian industry of the results of public sector R&D. Action on the recommendations of the Strategic Plan for CPDL, when it is ready, should be a high priority.
3. *National Coordination of Mineral S&T*. Provincial governments have proposed the concept of a Canadian Council of Research and Technology Centres with federal and provincial participation. Consideration should be given to such a forum, which would meet the need for national coordination and consultation on public sector R&D activities, programs and policies in Canada.

# International Marketing of Minerals

## Introduction

The Canadian mineral industry has evolved largely as a producer for foreign markets. While it has generally thrived under this export orientation, it has faced a number of persistent marketing difficulties. These unresolved problems, together with a number of changes in the international mineral environment, constitute important challenges to the mineral sector in the 1980s. Among these challenges are:

- The slowdown of growth rates in the world economy since 1974;
- The changing geographic patterns of industrial growth and mineral consumption;
- The emergence of new suppliers and expansion of established suppliers for most minerals;
- Continued protection against processed mineral imports through tariffs and nontariff barriers in "developed market economies" (DMEs) such as Japan, and especially in some "newly industrializing countries" (NICs) such as South Korea, Singapore, Taiwan, Brazil and Mexico;
- Discriminatory mineral procurement strategies of some major industrialized countries motivated by security of supply considerations; and
- International initiatives to manage mineral markets.

Canadian mineral enterprises generally have been quite successful in penetrating and maintaining export markets, and will undoubtedly continue to do so. But the Government of Canada has an important supporting role, as foreign governments continue to shape patterns of international mineral development and trade. Some foreign policies discriminate against Canadian minerals and mineral products, while others threaten to escalate unfair competitive practices, such as subsidized production. The federal government must deal with such foreign policies to defend Canada's interests as a mineral exporter in the coming years. This can be achieved by:

- Improving access to currently protected markets;
- Countering the unfair competitive practices inherent in the subsidization of other producers under security-of-supply rationalizations;
- Facilitating the export promotion activities of Canadian mineral enterprises; and
- Ensuring that Canadian mineral export interests are furthered — in balance with other objectives — in international arrangements designed to manage or shape the functioning of mineral markets.

Effective and aggressive bargaining strategies, as well as institutional innovations in the marketing of minerals, will be needed to realize these objectives.

## International Marketing Challenges of the 1980s

### World Forecasts of Mineral Demand and Prices

The first marketing challenge facing the Canadian mineral industry stems from the prospective slowdown in economic growth in the 1980s. Forecasters are quite unanimous that average growth rates for the DMEs will be significantly lower in the 1980s than during the preceding 20 years. However, while the forecast rates of the 1980s are below those of the 1960s, they are reasonably close to or better than the lower rates of the post 1974 period (see Table 1).

**Table 1. Economic growth for the world economy**

| | Actual | | Forecast (1980-90) | | | |
|---|---|---|---|---|---|---|
| | 1960-73 | 1973-79 | World Bank | DRI | Chase | Informetrica |
| | (%/year) | | | | | |
| Developed market economies | 4.9 | 2.5 | 3.2 | – | – | – |
| Canada | 6.4 | 2.6 | – | 3.6 | 2.8 | 3.4 |
| United States | 5.2 | 2.8 | – | 4.0 | 3.5 | – |
| Japan | 12.4 | 2.4 | – | 4.2 | 5.9 | 5.2 |
| EEC | 5.1 | 1.6 | – | 2.2 | – | 3.7 |
| Developing countries | 6.1 | 4.1 | 5.1 | – | – | – |
| Low-income oil importer | 4.2 | 3.0 | 3.6 | – | – | – |
| Middle-income oil importer | 6.4 | 4.6 | 5.0 | – | – | – |

SOURCE: World Bank, *World Development Report*, August 1981; Informetrica Post Workshop, June 1981; Chase, May 1981; DRI, September 1981.

Slower rates of economic growth — and especially in industral production — are likely to result in slower growth of mineral consumption. EMR projections of the international aluminum, nickel, copper, lead and zinc markets indicate that consumption growth will be a good deal lower from 1980-90 than in the preceding 20 years (Table 2). These projections are consistent for the most part with forecasts produced by Chase Econometrics and the World Bank, also presented in Table 2. World Bank forecasts were somewhat more optimistic, but these were carried out in late 1979 and so do not incorporate the depressive impacts of the 1979-80 oil price increases. Here are some of the factors that will shape the demand for specific minerals:

*Aluminum*. Slower industrial growth in the 1980s, compared to the 1950s and 1960s, is likely to restrict the expansion of aluminum demand, although it is expected to increase at almost

**Table 2. Growth rates of mineral consumption by Western world DMEs**

| | Actual | | Forecast (1980-90) | | | |
|---|---|---|---|---|---|---|
| | 1960-73 | 1973-79 | EMR | Chase | World Bank | Other |
| | (%/year) | | | | | |
| Aluminum | 9.5 | 3.2 | 4.0 | 4.3 | 7.0 | |
| Copper | 4.6 | 1.5 | 2.5 | 3.5 | 3.0 | 2.2* |
| Lead | 4.6 | 1.1 | 2.5 | 3.3 | 3.3 | |
| Nickel | 6.8 | 2.5 | 3.8 | 5.1 | 5.0 | 4.0† |
| Zinc | 5.4 | -0.6 | 2.8 | 4.2 | 5.1 | – |
| Potash | – | 6.2‡ | 4.3 | – | 4.9§ | – |

* Commodity Research Unit.

† Falconbridge.

‡ 1960-77.

§ 1977-90.

double the rate of other key metals. Table 4 shows substantial expected declines in growth rates for all regions, but relatively higher growth rates for developing countries. Aluminum fares better than other metals because of its light weight and anticorrosive properties, which make it especially useful for energy conservation in transportation applications.

*Copper*. Growth in copper consumption is expected to slow significantly for a number of reasons in addition to the generally slower growth of the world economy. The first is slower growth in the electrical-electronic, construction and transportation industries, which accounted for 46, 16 and 10 per cent respectively of total U.S. consumption in 1974. In particular, the very slow growth forecast for U.S. utilities — 1.4 per cent per year, 1979-90 — will have a depressing effect. Second, the DMEs have high stocks of many copper-containing end products; some markets are close to saturation and increased recycling is likely. Third, copper consumption will be affected by the intensified introduction of substitutes in telecommunications equipment and other applications.

*Zinc*. The growth in consumption of zinc in the Western world is also expected to slow significantly in the 1980s compared to the 1950s and 1960s, but be stronger than the 1970s due to a number of factors. The shift to smaller and lighter cars means that the automotive industry will require less zinc. General Motors estimates that the zinc content in its average car has decreased from 17 kilograms in 1975 to 7 kilograms in 1979, and will reach 4 kilograms by 1985. Increased competition from aluminum is another threat to zinc demand; as the aluminum/zinc price ratio continues to fall, galvalume — an aluminum/zinc-coated steel sheet — becomes favoured over the solely zinc-coated galvanized sheet. Broad changes in consumption patterns, with a larger portion of rising income spent on services rather than goods, will further dampen the relative rate of growth of zinc demand.

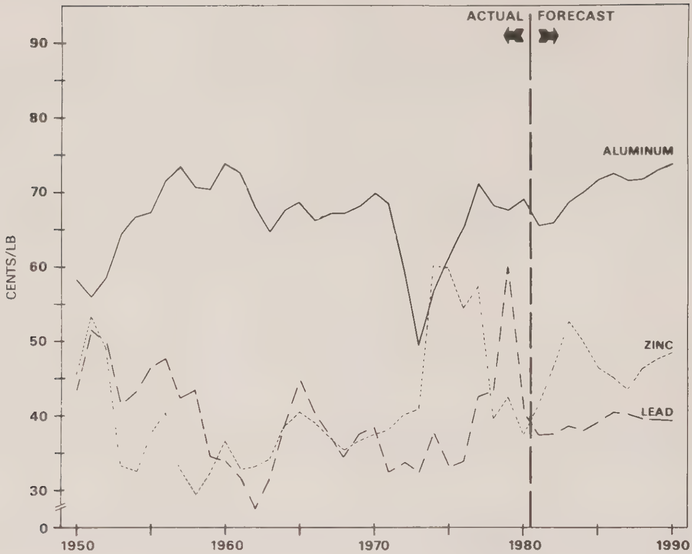
*Lead*. Growth in lead consumption is also expected to slow down in the 1980s compared to 1955-70, especially in the DMEs, although growth will be stronger than in the 1970s. Again, this is due not only to slower rates of industrial growth, but in this case also to sluggishness in automobile production, particularly in the United States and Canada, and the move to smaller cars that use smaller batteries requiring less lead. The continued phasing out of leaded gasoline will also reduce growth in lead consumption.

A relatively stronger demand for these metals is expected to occur in the lesser developed countries (LDCs) during the 1980s because of more rapid rates of industrial growth, particularly in the telecommunications, electronics, construction and transportation industries. This, however, will only partly offset the overall decline in DME markets. In addition, while relative rates of growth in LDCs will be higher, in absolute terms the LDCs will not constitute a significant market for Canadian minerals and metals for some time.

The slower rates of growth in mineral consumption, together with expected additions to global production capacity, lead to relatively pessimistic price projections for the 1980s. Price forecasts for major Canadian minerals are presented in Table 3, and some are pictured in Figures 1(a and b). General conclusions from these forecasts can be summarized as follows:

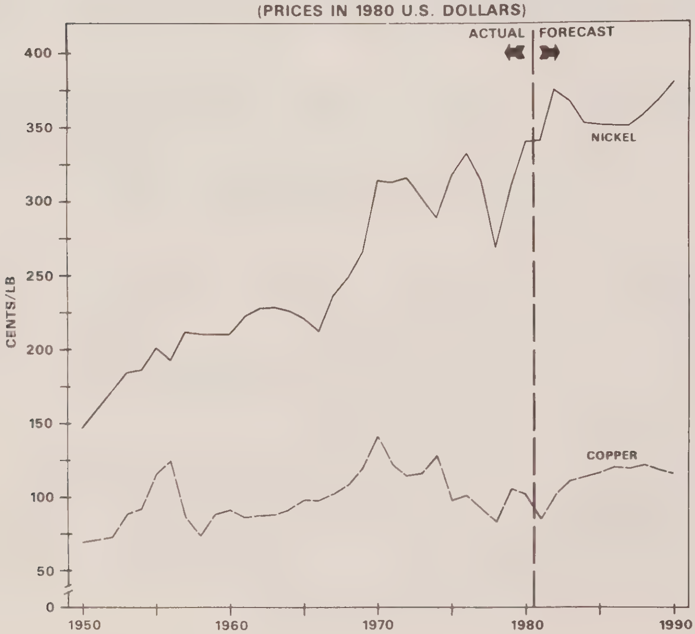
- *Copper* prices, while expected to increase in real terms above the low levels of 1977-80, are unlikely to reach the higher real levels of the 1950-70 period, particularly if large-scale mines come on stream in Peru and Chile.
- *Aluminum* prices are forecast to increase modestly in view of energy price increases from 1973 to 1980 and the high energy intensity of aluminum production.
- *Nickel* prices are forecast to increase in real terms modestly over the decade, in comparison with the 1972-80 period.
- *Lead* prices in real terms appear unlikely to rise much, if at all, over the decade and will likely be below the levels of the 1950s and 1960s.

FIGURE 1(a)
WORLD MINERAL PRODUCER PRICES
(PRICE IN 1980 U.S. DOLLARS)




SOURCE: Resource Srategy and Economic Analysis Branch, EMR, Econometric Model.

FIGURE 1(b)
WORLD MINERAL PRODUCER PRICES
(PRICES IN 1980 U.S. DOLLARS)




SOURCE: Resource Strategy and Economic Analysis Branch, EMR, Econometric Model

**Table 3. Indices of major mineral prices—past and projected, 1955–1980–1990***

| | Actual | | | | | | | | | | Forecast | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1955 | 1960 | 1965 | 1970 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
| *Copper* (LME) | 133.9 | 87.2 | 162.2 | 155.0 | 85.7 | 93.5 | 81.8 | 78.9 | 101.9 | 100.0 | 78.9 | 92.2 | 92.2 | 99.1 | 103.7 | 107.2 | 109.2 | 111.0 | 110.1 | 108.2 |
| *Aluminum* (Ingot, New York) | 97.3 | 107.1 | 99.3 | 101.3 | 88.6 | 94.4 | 102.9 | 98.6 | 98.1 | 100.0 | 98.1 | 101.2 | 106.3 | 105.8 | 108.2 | 108.2 | 106.3 | 107.6 | 109.7 | 110.3 |
| *Nickel* | 58.9 | 61.7 | 64.5 | 92.0 | 93.4 | 97.0 | 92.0 | 78.6 | 90.7 | 100.0 | 100.0 | 109.9 | 106.8 | 102.6 | 102.5 | 102.5 | 103.3 | 105.3 | 108.7 | 111.9 |
| *Lead* | 111.4 | 81.6 | 107.3 | 91.0 | 79.3 | 81.3 | 101.7 | 103.4 | 143.7 | 100.0 | 88.0 | 87.7 | 86.6 | 86.7 | 91.2 | 95.2 | 94.1 | 92.4 | 91.2 | 90.2 |
| *Zinc* | 100.8 | 98.3 | 108.3 | 99.6 | 159.9 | 145.1 | 127.1 | 106.1 | 113.5 | 100.0 | 104.1 | 112.5 | 141.5 | 145.9 | 141.3 | 137.2 | 133.9 | 129.3 | 132.2 | 129.6 |

SOURCE: Resource Strategy and Economic Analysis Branch, EMR.

* 1980 = 100, 1980 constant $.

- *Zinc* prices are forecast to increase in real terms in the 1980s, and to maintain high levels in relation to earlier decades.

Since Canadian production costs will likely increase more rapidly than the projected global rate of inflation in the coming decade, the foregoing mineral price projections — excluding zinc, perhaps — must be viewed with more pessimism than the numbers suggest. Energy prices in Canada will continue to be below the level of world prices. Capital costs tend to escalate more rapidly than overall rates of inflation. Moreover, any appreciation of Canada's currency in the years ahead could quickly nullify the domestic-currency equivalent of higher international prices (in $U.S.). Nevertheless, Canada is and will continue to be highly competitive in most minerals (see *Competitive Position*).

Consumption and price projections are affected significantly by the assumptions of future rates of global economic growth. Figure 2 illustrates the EMR price forecasts when global growth rates, 50 per cent higher and 50 per cent lower than the most probable growth rates, are fed into the predictive models. Metals prices, with the exception of lead, appear to be highly responsive to alternate growth assumptions, as would be expected.

## Changing Patterns of Industrial Growth and Mineral Consumption

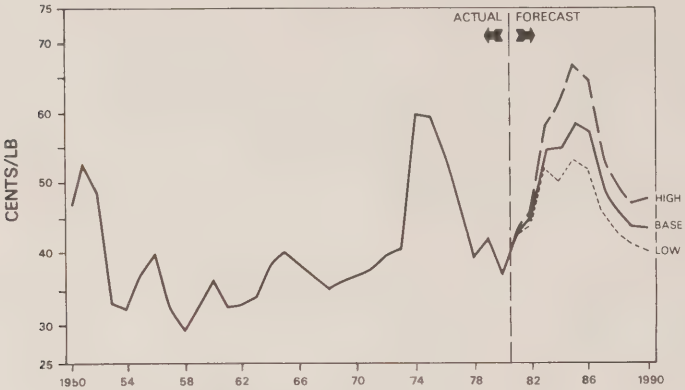
Patterns of international industrial growth have shifted in the post-war era and are projected to change further. A second basic challenge for the Canadian mineral sector is to capitalize on such shifts. Of special interest here is the industrial expansion of developing countries, where industrial growth exceeded that of the DMEs from 1960 to 1979. The middle-income developing countries have entered growth phases in which industry is expanding as a percentage of GDP, in contrast to the increasingly service-oriented DMEs. (See Table 1 for detail on patterns of international industrial growth.)

Changes in patterns of mineral consumption accompany such changes in industrial growth. As can be seen in Table 4, prospective growth rates of mineral consumption in the LDCs exceed those of the DMEs significantly. The LDCs, of course, started from lower base levels of consumption, as did Japan, but their consumption shares have increased substantially and are projected to increase further in the 1980s — to 11.1, 13.2, 13.2 and 20.9 per cent for aluminum, copper, lead and zinc, respectively. Increases in mineral consumption in the LDCs may even be underestimated if the current trend towards more export-oriented strategies continues to intensify.

FIGURE 2(a)

## SENSITIVITY ANALYSIS: ZINC PRICE PROJECTIONS UNDER ALTERNATE GLOBAL GROWTH ASSUMPTIONS(1)

PRICES IN 1980 U.S. DOLLARS



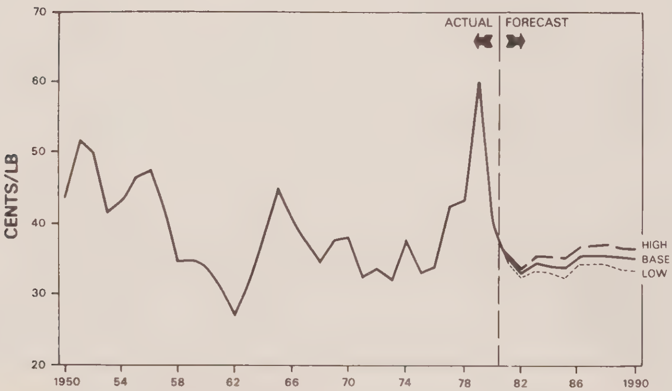

HIGH 50% HIGHER ECONOMIC GROWTH
LOW 50% LOWER ECONOMIC GROWTH

SOURCE: Resource Strategy and Economic Analysis Branch, EMR, Econometric Model

FIGURE 2(b)

## SENSITIVITY ANALYSIS: LEAD PRICE PROJECTIONS UNDER ALTERNATE GLOBAL GROWTH ASSUMPTIONS (1)

PRICES IN 1980 U.S. DOLLARS




(1) HIGH 50% HIGHER ECONOMIC GROWTH
LOW 50% LOWER ECONOMIC GROWTH

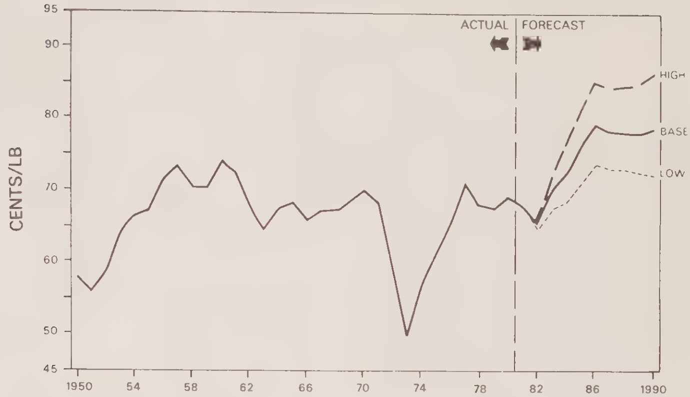


SOURCE: Resource Strategy and Economic Analysis Branch ,EMR, Econometric Model

FIGURE(2c)

## SENSITIVITY ANALYSIS: ALUMINUM PRICE PROJECTIONS UNDER ALTERNATIVE GLOBAL GROWTH ASSUMPTIONS (1)

PRICES IN 1980 U.S. DOLLARS



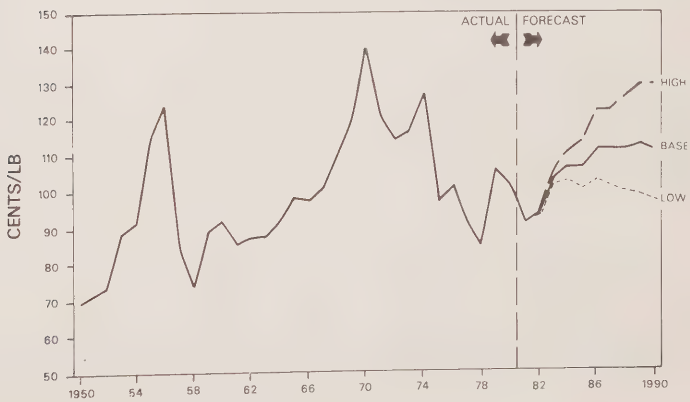

(1) HIGH 50% HIGHER ECONOMIC GROWTH
LOW 50% LOWER ECONOMIC GROWTH

SOURCE: Resource Strategy and Economic Analysis Branch, EMR, Econometric Model

FIGURE 2(d)

## SENSITIVITY ANALYSIS: COPPER PRICE PROJECTIONS UNDER ALTERNATE GLOBAL GROWTH ASSUMPTIONS (1)

PRICES IN 1980 U.S. DOLLARS




(1) HIGH 50% HIGHER ECONOMIC GROWTH
LOW 50% LOWER ECONOMIC GROWTH

SOURCE: Resource Strategy and Economic Analysis Branch, EMR, Econometric Model

**Table 4. Patterns of world mineral consumption—past and prospective**

| | | Canada | United States | Western Europe | Japan | Africa | Rest of America | Other Asia | Oceania | Total Western world | CPEs | Total world |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (%) | | | | | | | | | | |
| *Aluminum* | | | | | | | | | | | | |
| Market shares | 1955 | 2.7 | 50.9 | 26.3 | 1.6 | 0.2 | 1.0 | 0.7 | 0.5 | 83.9 | 16.1 | 100.0 |
| | 1979 | 2.2 | 31.4 | 24.3 | 11.3 | 0.8 | 3.5 | 3.9 | 1.5 | 78.9 | 21.1 | 100.0 |
| | 1990 | 2.4 | 28.4 | 23.5 | 10.9 | 1.3 | 5.2 | 4.6 | 1.8 | 78.1 | 21.9 | 100.0 |
| Growth rates | 1955-70 | 6.7 | 5.4 | 8.1 | 21.4 | 17.2 | 13.6 | 19.4 | 15.0 | 7.7 | 10.0 | 8.1 |
| | 1970-79 | 5.3 | 4.1 | 4.5 | 7.9 | 6.1 | 12.0 | 8.5 | 6.4 | 5.3 | 5.4 | 5.3 |
| | 1980-90 | 6.3 | 3.7 | 3.3 | 4.2 | 5.4 | 6.8 | 4.7 | 5.6 | 4.0 | 4.1 | 4.0 |
| *Copper* | | | | | | | | | | | | |
| Market shares | 1955 | 3.3 | 36.2 | 38.9 | 2.8 | 0.6 | 2.1 | 0.9 | 1.4 | 86.2 | 13.8 | 100.0 |
| | 1979 | 2.5 | 22.6 | 28.7 | 13.5 | 0.9 | 4.7 | 2.7 | 1.3 | 76.9 | 23.1 | 100.0 |
| | 1990 | 2.1 | 21.7 | 26.3 | 12.5 | 1.5 | 7.9 | 3.8 | 1.4 | 77.2 | 22.8 | 100.0 |
| Growth rates | 1955-70 | 4.1 | 2.1 | 3.6 | 14.7 | 4.6 | 5.5 | 7.7 | 5.3 | 4.0 | 7.1 | 4.5 |
| | 1970-79 | 0.7 | 2.1 | 1.5 | 5.5 | 8.8 | 10.9 | 11.6 | 1.4 | 2.9 | 5.1 | 3.4 |
| | 1980-90 | 1.9 | 3.5 | 1.0 | 1.4 | 4.7 | 7.0 | 4.7 | 3.1 | 2.5 | 2.2 | 2.4 |
| *Lead* | | | | | | | | | | | | |
| Market shares | 1955 | 2.3 | 32.7 | 39.1 | 1.9 | 0.8 | 2.8 | 0.9 | 2.5 | 83.0 | 17.0 | 100.0 |
| | 1979 | 2.2 | 24.4 | 30.4 | 4.9 | 1.6 | 5.2 | 3.5 | 1.5 | 73.8 | 26.2 | 100.0 |
| | 1990 | 1.9 | 24.7 | 28.3 | 5.1 | 2.3 | 6.4 | 4.5 | 1.6 | 74.8 | 25.2 | 100.0 |
| Growth rates | 1955-70 | 3.1 | 3.1 | 2.6 | 11.0 | 4.9 | 6.4 | 9.6 | 0.8 | 3.4 | 6.1 | 3.9 |
| | 1970-79 | 4.1 | 1.1 | 2.2 | 2.7 | 8.9 | 6.0 | 9.5 | 2.1 | 2.5 | 4.3 | 2.9 |
| | 1980-90 | 1.7 | 3.7 | 0.9 | 1.4 | 4.4 | 4.8 | 5.7 | 1.6 | 2.5 | 1.0 | 2.1 |
| *Nickel* | | | | | | | | | | | | |
| Market shares | 1955 | 2.4 | 48.3 | 25.2 | 1.6 | | 0.8 | | | 78.3 | 21.7 | 100.0 |
| | 1979 | 1.5 | 23.4 | 29.7 | 16.9 | | 4.4 | | | 75.9 | 24.1 | 100.0 |
| | 1990 | 1.6 | 21.5 | 27.0 | 17.5 | | 7.0 | | | 74.6 | 25.4 | 100.0 |
| Growth rates | 1955-70 | 7.6 | 2.7 | 8.4 | 25.2 | | 16.6 | | | 7.1 | 7.0 | 7.1 |
| | 1970-79 | –2.4 | 2.3 | 3.2 | 3.2 | | 11.2 | | | 3.1 | 4.6 | 3.5 |
| | 1980-90 | 4.3 | 3.8 | 2.8 | 4.1 | | 6.4 | | | 3.8 | 3.3 | 3.6 |
| *Zinc* | | | | | | | | | | | | |
| Market shares | 1955 | 2.0 | 37.5 | 34.3 | 4.0 | 0.9 | 1.9 | 1.4 | 2.7 | 84.7 | 15.3 | 100.0 |
| | 1979 | 2.5 | 15.8 | 26.9 | 12.3 | 1.9 | 5.3 | 7.0 | 1.9 | 73.6 | 26.4 | 100.0 |
| | 1990 | 2.4 | 12.2 | 24.4 | 11.2 | 2.6 | 7.7 | 10.6 | 1.9 | 73.0 | 27.0 | 100.0 |
| Growth rates | 1955-70 | 4.8 | 0.4 | 3.4 | 12.4 | 9.7 | 8.2 | 11.6 | 3.7 | 3.6 | 8.1 | 4.3 |
| | 1970-79 | 4.3 | -0.8 | 2.0 | 2.5 | 5.4 | 8.2 | 9.1 | -0.3 | 2.0 | 4.2 | 2.6 |
| | 1980-90 | 3.6 | 1.7 | 1.2 | 1.5 | 4.4 | 6.3 | 8.6 | 1.9 | 2.8 | 2.1 | 2.6 |
| *Potash* | | | | | | | | | | | | |
| Market shares | 1960 | 1.0 | 23.6 | n.a. | 6.3 | 1.1 | 1.7 | 1.6 | n.a. | 77.1 | 22.9 | 100.0 |
| | 1977 | 1.1 | 23.0 | n.a. | 3.0 | 1.5 | 4.3 | 3.4 | n.a. | 58.7 | 41.3 | 100.0 |
| Growth rates | 1960-77 | 6.9 | 6.0 | n.a. | 1.7 | 8.1 | 12.3 | 11.1 | n.a. | n.a. | | 6.2 |

SOURCE: World Bureau of Metal Statistics, *World Metal Statistics*, various issues for 1955-79 data, Resource Strategy and Economic Analysis Branch, EMR, for projections.

n.a.—not available.

Although the major markets for Canadian minerals undoubtedly will continue to be the United States, Japan and Europe, possible reorientation of Japanese and European import patterns, plus slow growth in the U.S. market, suggest that Canada should also be promoting other markets — particularly potential markets for more finished products. LDC markets would be potential targets for such a thrust, even though many are protected by high tariff barriers, and despite additional supplies from new LDC producers and expanded mineral output from some older producers, which tend to reduce the market potential for Canadian minerals in these areas.

## Changing Patterns of Mineral Production

Canada's mineral industry will likely face intensifying competition in the coming years as more countries develop their mineral resources or expand capacity for export markets. In the post-war period, Canada's shares of world mineral production evolved in varying ways (Table 5). Shares of mine production fell sharply for some minerals from 1951 to 1979: gold, from 12.9 to 4.1 per cent; silver, from 12.3 to 10.9 per cent; nickel, from 74.4 to 18.6 per cent. Shares of smelted and refined copper, aluminum, refined nickel and asbestos also fell sharply. Uranium market shares fell from 1960 to 1979. On the other hand, potash production shares rose from zero to 23.6 per cent from 1960 to 1979. Mine production of lead and zinc also increased in this period.

Future mineral production shares for Canada vis-à-vis other countries will be the direct result of current and planned patterns of international investment in mineral development. In this regard, there has been a fundamental shift in the geographical pattern of exploration

**Table 5. Canadian mineral production shares***

| | | 1951 | 1960 | 1969 | 1979 | 1980 |
|---|---|---|---|---|---|---|
| | | | | (%) | | |
| Aluminum, smelted | | 22.4 | 15.2 | 10.3 | 5.7 | 8.4 |
| Copper | Mined | 9.2 | 9.7 | 8.8 | 8.0 | 9.1 |
| | Smelted | 8.1 | 8.8 | 6.5 | 4.7 | 6.2 |
| | Refined | 6.9 | 7.6 | 6.9 | 4.3 | 5.4 |
| Lead | Mined | 8.3 | 7.8 | 9.2 | 9.4 | 8.2 |
| | Smelted | 7.8 | 5.3 | 4.4 | 4.5 | 4.3 |
| Zinc | Mined | 12.9 | 11.4 | 22.1 | 19.0 | 17.1 |
| | Smelted | 9.1 | 7.6 | 8.1 | 9.0 | 9.6 |
| Nickel | Mined | 74.4 | 61.0 | 37.6 | 18.6 | 25.9 |
| | Refined | 43.2 | 38.7 | 27.7 | 12.4 | 20.1 |
| Silver | Mined | 12.3 | 14.3 | 14.7 | 10.9 | – |
| Potash | | 0 | 0 | 19.0 | 23.6 | – |
| Gold | | 12.9 | 10.3 | 6.0 | 4.1 | – |
| Asbestos | | 62.0 | 41.4 | 47.0 | 31.2 | – |
| Uranium | | – | 26.5 | 18.0 | 18.1 | – |

SOURCES: Metallgesellschaft, *World Metal Statistics*; annual, various issues; World Bank, *World Potash Survey*, September 1978.

* Canadian production as a percentage of total world production.

expenditures in the 1960s and 1970s — a shift away from the developing countries and towards the developed market economies. A survey of the exploration investment of 14 European mining firms showed that the DME share of these expenditures increased from 43 to 85 per cent from 1961 to 1975. Similarly, a survey of 18 U.S. and Canadian mining companies indicated that more than 80 per cent of their exploration expenditures were in the DMEs.[1] Other estimates confirm that exploration has moved out of the LDCs and into the DMEs — H. Brownrigg[2] presents the following estimates of the LDCs shares — 1961-65, 35 per cent; 1966-70, 30 per cent; 1971-75, 14 per cent. It therefore seems evident that mining will become more of an activity of the DMEs and NICs in the coming decades.

What shares of this activity can the Canadian industry expect? Judging from the surveys of capital investment plans and Canada's current competitive position, it appears probable that Canada's mine production shares will be maintained. Lead and zinc mine production shares may increase. Potash production should increase dramatically as a proportion of world production. Future changes in market shares for smelted aluminum and for mine production of gold and uranium are more uncertain.

## Changing Mineral Market Structures

Generally speaking, international mineral markets have become more competitive, with reduced levels of concentration both by corporate grouping and by country.

In aluminum production, the shares of the "Big Six" in bauxite, alumina and aluminum capacity as proportions of total Western world capacity fell from 1968 to 1978. The share of Alcan specifically also was reduced in all phases of the industry. In copper, there has been a dramatic reduction in levels of corporate concentration, arising from the nationalizations of the early 1970s, the growth of smaller companies, and the emergence of Japanese companies. The nickel industry was a tight oligopoly dominated by Inco. Market shares of Canadian producers in 1955 were 67.1 per cent for Inco, 9.4 per cent for Falconbridge, and 6.5 per cent for Sherritt Gordon. By 1976, however, these shares had fallen to 35.0, 6.1 and 2.1 per cent respectively of the total Western World market. In lead production, corporate concentration changed little from 1966 to 1978, and perhaps increased slightly. However, the market share of Canada's largest producer, Cominco, fell somewhat.

Reduced corporate concentration in these important mineral markets certainly does not mean that mineral markets as a whole are competitive. For many lesser minerals, substantial power to control supplies rests with a few dominant private corporations. Diamonds, lithium, zirconium and rutile are key examples.

The pattern of concentration of mineral production *by country* has evolved in a variety of ways for different minerals in the post-war era. Using criteria of production shares for individual countries, most mineral markets of special significance to Canada became less concentrated, notably for aluminum, nickel (mined and refined), copper (mined, smelted and refined), silver (mined), uranium and perhaps lead. Gold production became significantly more concentrated in South Africa from 1951 to 1969, but appears to be somewhat less so from 1969 to 1979. Market shares have changed in the cases of potash and asbestos, but whether production is more or less concentrated by country is ambiguous, depending on the criterion of concentration employed.

Future corporate concentration and country shares of mineral production are difficult to predict, but projections undertaken by the World Bank indicate that country concentration of

[1] R. Mikesell, *New Patterns of World Mineral Development*, 1979, p. 23-29.
[2] H. Brownrigg, *Stabilizing the Political Risk Environment in the International Mining Industry*, London Business School, 1977.

mineral production will likely be reduced substantially in future for copper, nickel and aluminum, and to a lesser degree for lead and zinc as well.

Important implications for Canada arise from less concentrated market structures. First, a proliferation of producers of most minerals exported by Canada will increase competitive pressure on Canadian producers. The reduction of oligopolistic power for Canadian producers will also increase their vulnerability to market pressures. Second, reduced concentration in mineral production and reduced vertical integration from mine-mouth to final goods may intensify cyclicality of mineral prices and investment pattern — concentration of production and vertical integration usually generate price stability, while competition and a lack of vertical integration normally generate price instability and cyclicality.

An important structural change in some mineral markets is the shift of ownership from international mining companies to host governments. This is particularly the case with copper, where government enterprises now exercise control in Zaire, Zambia, Papua New Guinea, Chile and Peru, and have majority ownership in the Philippines and Mexico. Approximately 34 per cent of Western world copper production originates in government controlled enterprises.

State ownership in LDCs raises concern among private mining firms for several reasons. Due to their need for foreign exchange earnings from mineral exports, they may be less likely to reduce production when demand shrinks. This would exert greater downward pressure on price, may require larger cutbacks by private firms in the DMEs and may impair their ability to invest in new capacity. Second, state enterprises in LDCs may not undertake sufficient exploration, so that the long-term availability of minerals may be limited. Third, they may invest on social grounds even if rates of return are low, so that excessive amounts of new capacity are brought on stream.

In summary, future mineral market structures are likely to be characterized by:

- Continuing reductions in geographic concentration as more countries expand or begin mineral production;
- Continuing reductions in corporate concentration — as LDCs opt for majority ownership and control, as private firms in Japan and some LDCs expand or begin production — but with a major continuing role for international mining enterprises;
- Continuing oligopoly or near-monopoly in many minor mineral markets;
- Continuing uncertainty arising from the behavioural complexities of state enterprises in LDCs; and
- Continuing and perhaps intensifying price volatility in those mineral markets where corporate and geographical concentration is weakening.

## Access to Markets: Tariffs and Nontariff Barriers

Canada's mineral exports face escalating tariff structures in major markets and also in middle-income countries of high market potential (Tables 6 and 7). Nominal tariff rates are usually zero for mineral ores, but rise to higher levels as the degree of processing increases. Escalation of tariff structures is particularly pronounced in middle-income countries such as Brazil, Venezuela and South Korea. The true protective impact of tariff rates is much higher than suggested by the nominal rates, when the value added by a protected processing activity is relatively low. Rates of nominal and effective protection in Japan, the United States and the EEC were reduced somewhat by the "Tokyo Round" of the GATT negotiations, but they remain significant.

Nontariff barriers of various kinds also restrict access for processed and fabricated products. These are often constructed so as to benefit domestic suppliers at the expense of foreign

**Table 6. Tariffs facing Canadian mineral exports—pre- and post-Tokyo round**

| | | EEC | | | Japan | | | United States | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Pre | Post | GSP | Pre | Post | GSP | Pre | Post | GSP |
| *Iron* | Iron ore | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Pig iron | 3.0 | 2.2 | 0.0 | 6.0 | 4.3 | 0.0 | 1.7 | 1.5 | 0.0 |
| | Steel ingots | 6.6 | 5.7 | 0.0 | 7.8 | 5.0 | 0.0 | 3.2 | 2.5 | 0.0 |
| | Mill products | 6.6 | 4.9 | 0.0 | 8.3 | 5.2 | 0.0 | 7.0 | 4.4 | (part) |
| | Special steels | 8.0 | 5.3 | (excl.) | 7.5 | 4.9 | 0.0 | 4.7 | 3.2 | – |
| *Copper* | Ore | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 |
| | Unwrought | 0.0 | 0.0 | 0.0 | 5.7 | 4.8 | 0.0 | 1.4 | 1.0 | 0.0 |
| | Wrought | 8.0 | 6.0 | (part) | 17.3 | 6.8 | 0.0 | 4.3 | 2.6 | 0.0 |
| *Aluminum* | Unwrought | 6.8 | 5.8 | 0.0 | 8.6 | 8.5 | 0.0 | 2.0 | 0.0 | 0.0 |
| | Wrought | 11.8 | 9.7 | 0.0 | 16.5 | 11.7 | 0.0 | 3.7 | 2.9 | 0.0 |
| *Lead* | Ore | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.8 | 0.0 | 0.0 |
| | Unwrought | 2.9 | 2.9 | 0.0 | 4.6 | 4.3 | 0.0 | 5.1 | 3.0 | 0.0 |
| | Wrought | 9.7 | 7.8 | 0.0 | 10.2 | 6.4 | 0.0 | 7.9 | 7.6 | 0.0 |
| *Zinc* | Ore | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 |
| | Unwrought | 3.5 | 3.5 | 0.0 | 3.7 | 3.7 | 0.0 | 2.0 | 1.5 | 0.0 |
| | Wrought | 10.0 | 8.0 | (part) | 10.0 | 5.8 | 0.0 | 0.8 | 0.8 | 0.0 |
| *Nickel* | Ore | 0.0 | 0.0 | 0.0 | – | – | 0.0 | 0.0 | 0.0 | 0.0 |
| | Unwrought, unalloyed | 0.0 | 0.0 | 0.0 | Y150/kg | Y81/kg | 6.5% or Y75/kg | 0.0 | 0.0 | 0.0 |
| | Wrought | – | – | 0.0 | 22.5% | 9% +0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Alloyed | – | – | – | – | – | 0.0 | – | – | – |

SOURCES: IMF, *Trade Effects of the Generalized System of Preferences*, April 1975, p. 26, UNCTAD Document no. TD/BC/C.1/207/Add.2/ Aug. 14, 1980.

excl.—all items in the group are excluded from the scheme.

part—some items are excluded and some are included.

producers. A common pattern involves duty-free importation of ores and concentrates, together with tariffs and/or quantitative restrictions on processed and fabricated products, public procurement policies favouring domestic suppliers, special subsidization or tax incentives for exports, and perhaps direct subsidization.

The pattern of mineral protection in Japan is of particular concern to Canadian efforts to upgrade exports towards refined metals and semifabricates. The Japanese system of protection for copper metal, for example, consists of the following:

- Tolerance by the Japanese government of a coordinated "producer price" for refined copper, which ranges from 5 to 11 per cent above the London Metal Exchange price;
- Protection of the higher domestic price by tariffs on refined copper, which ranges from 25 to 40 per cent effective protection of the processing activity;
- Added protection of the higher domestic price by administrative controls — direct regulation of the quantities of copper imported;
- Direct subsidization of processing, such as the refunding of the turnover tax to smelters; and
- Zero tariffs on copper ores and concentrates.

This system makes market penetration for Canadian refined and semifabricated copper exports most difficult, and makes it possible for the Japanese smelters to pay a premium to

**Table 7. Tariffs on selected mineral products in some middle income countries**

| | | Brazil | Mexico | Venezuela | Malaysia |
|---|---|---|---|---|---|
| | | (%) | | | |
| *Copper* | Smelted, unrefined | 15 | 2 | 5 | 0 |
| | Refined | 15 | 12 | 10 | 0 |
| | Bars, shapes, rods angles | 17–45 | 40 | 10–60 | 0–20 |
| | Alloys | 15–20 | | 1–20 | 0 |
| | Plates, sheet | 145 | 30–40 | 40 | 0 |
| | Tubes, pipes | 55–145 | 25 | 70 | 0 |
| | Wire and cable | 85 | 25 | 60 | 20 |
| | Other articles | 100–170 | 15–80 | 5–60 | 0–25 |
| *Nickel* | Unwrought | 15 | 5 | 1 | 0 |
| | Wrought | 20–30 | 5–30 | 10–25 | 10 |
| | Piping | 60 | 10 | 10 | 10 |
| | Other articles | 155 | 15 | 20 | 10 |
| *Aluminum* | Unwrought | Free | 0 | 10 | 0 |
| | Wrought | 37 | 5–30 | 60 | 0–30 |
| | Tubes and pipes | 75 | 30 | 70 | 30 |
| | Construction material | 160 | 15 and 40 | 60 | 35 |
| | Other manufactures | 60–170 | 10–50 | 25–100 | 0–30 |
| *Lead* | Unwrought | 30 | 10 | 15 | 0 |
| | Wrought | 37–67 | 15–25 | 20–25 | 0 |
| | Other manufactures | 67–170 | 25 | 50 | 0 |
| *Zinc* | Unwrought | 30 | 10 | 15 | 0 |
| | Wrought | 20–145 | 9–15 | 20–60 | 0–15 |
| | Other manufactures | 75–170 | 20 | 50–60 | 0–25 |

SOURCE: National tariff schedules for the above countries.

Canadian exporters of concentrate, so there is a disincentive to establish smelters and refineries in the Canadian West. While Japanese protective systems are currently of greatest concern to Canada, the recent proliferation of similar protective arrangements for smelted and refined copper — in South Korea, Taiwan, Brazil and elsewhere — also merits attention.

## Marketing Arrangements Affecting Terms of Trade

In order to stabilize export earnings, and in some cases to increase them, a variety of attempts have been made to manage international mineral markets through commodity agreements, producer associations, and cartels (Table 8). These have borne little fruit so far, and are unlikely to do so in the 1980s. Despite the international agreement to establish the United Nations Conference on Trade and Development (UNCTAD) "Common Fund" — which has not yet been ratified — no *new* workable commodity agreements for minerals have been successfully negotiated.

The most problematic case for Canada is copper. EMR conducted a study[1] of the various copper market management schemes proposed under the aegis of the Integrated Program for Commodities of UNCTAD, and their potential effects on Canadian interests. The study

[1] Resource Strategy and Economic Analysis Branch, EMR, *Stabilizing the International Copper Market: The Distributional and Stabilization Impacts and the Viability of Alternate Market Management Arrangements*, March 1980.

**Table 8. International market management for major minerals (included in UNCTADs integrated program for commodities)**

| Mineral | Proposed international action (UNCTAD) | Negotiations status | Prospects | Impact on Canada |
|---|---|---|---|---|
| *"Core" minerals* | | | | |
| Copper | International Commodity Agreement | Stalled after 17 meetings (due to intransigence of major protagonists) | No action | (Continuing price volatility) |
| Tin | Renegotiation of Tin Agreement | Reconvening for renewal | Renewed Agreement with or without U.S. participation | Minimal |
| *"Other" minerals* | | | | |
| Bauxite | No action proposed yet | No negotiations or discussions of negotiations | No action | None |
| Manganese | No action proposed yet | "Preparatory" meetings only<br>No negotiations | No action | None |
| Iron ore | No action proposed yet | "Preparatory" meetings only<br>No negotiations | No action | None |
| Phosphates | No action proposed yet | "Preparatory" meetings only<br>No negotiations | No action | None |

SOURCE: UNCTAD Secretariat, *Progress under Conference Resolution 93(IV)*, TD/B/IPC/AC 34, September 1980.

indicated that, depending upon how an international copper agreement was designed, a substantial investment might generate relatively little price stabilization, and might do so at the cost of reduced revenues to producers over the copper price cycle. The basic administrative viability of such a scheme is also questionable.

The copper "prenegotiations" are stalled, despite the current incentive to action — for producers at least — afforded by low copper prices. It is unlikely that any agreement can be reached in the near future because of the intransigence of major delegations with incompatible positions.

While a renewed *International Tin Agreement* has been negotiated, its impact on Canada appears minimal. No discussions for bauxite have yet taken place under UNCTAD. Discussions for manganese, phosphates and iron ore have as yet led to no negotiations, and are unlikely to do so in the near future. Other minerals are not included in UNCTAD's Integrated Program for Commodities and are not at this time likely to be targets for this type of international market management.

A variety of attempts was made in the 1970s to establish cartels for certain minerals to manage supply and raise prices OPEC-style. While the International Bauxite Association appeared to have had some temporary success, the copper association — Conseil Intergouvernemental des Pays Exportateurs de Cuivre (CIPEC) — and the Association of Iron Ore Exporting Countries had no success. Estimates suggest that the viability of such schemes would

be very limited for minerals of major export interest to Canada and the LDCs.[1] For bauxite, phosphates and tin, a viable cartel could damage Canadian interests as an importer. At this time, most producer associations such as CIPEC are relatively innocuous, and are concerned more with the collection and exchange of information and market analysis than with attempts at predatory cartel-style behaviour.

## Mineral Supply Strategies of Major Industrial Countries

In recent years, Japan, West Germany, France and the United States have developed policies and programs to increase security of supplies of strategic minerals (Table 10). So far, these strategies probably have not hurt Canadian mineral export interests in a serious way. However, they are worrisome and may become harmful in future. At the same time, there may be opportunities for Canada itself to become a secure supplier — as long as it does not assume a role as the secure supplier of "last resort", to be held in reserve until supplies from less secure sources have been disrupted.

The bilateral mineral component of the "Lomé II" agreement between the European Economic Community and the ACP countries — basically, former European colonies in *A*frica, the *C*aribbean and the *P*acific area — is designed to provide mineral development assistance to ACP and, simultaneously, supply security to EEC. This is to be achieved by providing (a) a type of "accident insurance" through which concessionary funding ($U.S. 372 million total) may be provided for projects to restore production when impaired by local "disasters" or economic factors and (b) technical and financial assistance for both fuel and nonfuel mineral exploration and development in ACP ($U.S. 235 million total).

These programs could generate benefits for Canada as a net importer of phosphates, bauxite, alumina, tin and manganese, if new ACP capacity holds prices down and helps secure global supplies. Only in copper and iron ore would there be possible harmful effects on Canada, if these programs helped provide a competitive edge to copper producers in Zaire, Zambia and Papua New Guinea, or iron ore producers in Liberia and Mauritania. But the volume of funding involved so far suggests that there is little for Canadian producers to fear from Lomé II.

The policies outlined in Table 10 are potentially of great significance to Canada since they could result in expanded mineral development in other regions, with favourable taxation, credit and insurance treatment of non-Canadian enterprises. Japan's policies may further diversify its sources of supply, and help integrate certain Pacific Rim producers effectively into a Japan-centred economic sphere. Further development in this direction could impair Canada's ability to develop its minerals sector, especially on the West Coast, in an integrated pattern of diversified industrialization based on mining activity.

Canada could take advantage of its position as a secure supplier and provide long-term contracts to countries concerned with procurement security, and so enlarge international markets for exports. Canada also will continue to be conscious of the interest of its major trading partners in maintaining secure supplies of minerals, and consider how measures to meet this need may be translated into greater access for other Canadian products as well. There are very important limitations on the extent to which this can be done, and therefore detailed study is required before formulating specific initiatives.

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[1] Virtually all studies of the potential viability of mineral cartels have arrived at the conclusion that they are by and large unworkable for more than a relatively short period of time. See R.S. Pindyck, *Gains to Producers from the Cartelization of Exhaustible Resources*, Working Paper, Energy Laboratory, MIT, 1976; R.S. Mikesell, *International Collusive Action in World Markets for Nonfuel Minerals*, U.S. Department of State, 1974; S. Rose, *Third World Commodity Power is a Costly Illusion*, Fortune, Nov. 1976. Some estimates of cartel viability as of 1981 are included in Table 9.

**Table 9. Probable viability of mineral cartels—an impressionistic summary**

| | | Without Canadian and Australian participation | | | | | | | | With Canadian and/or Australian participation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weights | Petroleum | Bauxite | Phosphates | Copper | Tin | Iron ore | Zinc | Lead | Bauxite | Iron ore | Copper | Zinc | Lead | Asbestos | Nickel | Potash | Uranium |
| Concentration of production and exportation in LDCs (and Canada and Australia in the second cases) | 20 | 18 | 16 | 16 | 10 | 17 | 8 | 4 | 2 | 18 | 16 | 15 | 13 | 13 | 8 | 4 | 8 | 4 |
| Income elasticity of demand | 15 | 15 | 14 | 12 | 10 | 3 | 9 | 7 | 3 | 14 | 9 | 10 | 7 | 3 | 5 | 12 | 12 | 12 |
| Price elasticity of demand | 20 | 18 | 13 | 19 | 14 | 19 | 19 | 17 | 17 | 13 | 19 | 14 | 17 | 17 | 14 | 18 | 10 | 18 |
| Price elasticity of supply in nonmember DMEs | 15 | 12 | 8 | 5 | 7 | 6 | 4 | 2 | 1 | 11 | 7 | 9 | 7 | 7 | 5 | 12 | 3 | 8 |
| Relative dispersion of major buyers | 5 | 4 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 1 |
| Recyclability; existence of scrap market | 5 | 5 | 1 | 5 | 1 | 1 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 4 | 2 | 5 | 5 |
| Financial strength of members | 5 | 5 | 1 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 3 |
| Production homogeneity among members | 5 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 4 | 1 | 1 | 2 |
| Presence of vertically integrated MNCs | 10 | 8 | 10 | 5 | 2 | 2 | 6 | 8 | 8 | 10 | 8 | 4 | 8 | 8 | 6 | 7 | 2 | 5 |
| Total scores | 100 | 87 | 69 | 70 | 51 | 56 | 52 | 47 | 41 | 75 | 66 | 59 | 59 | 55 | 53 | 62 | 49 | 58 |

SOURCE: Modified Calculations and Estimates based on A. Ritter, "Conflict and Coincidence of Canadian and LDC Interests in International Trade in Primary Commodities," Economic Council of Canada, *Discussion Paper 109*, 1978.

Sources and "scoring system": (corresponding with the numbers in table)

1. Score is calculated by (i) taking 20% of LDC market share; (ii) and modifying impressionistically on the basis of concentration among LDC exporters. High scores indicate concentration.
2. *Ibid.* Scoring conversion scale is as follows:

| Score: | 20 | 18 | 16 | 14 | 12 | 10 | 8 | 6 | 4 | 2 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Income elasticity: | 0.05 | 0.15 | 0.3 | 0.95 | 0.6 | 0.70 | 0.85 | 1.0 | 1.2 | 1.5 | 2.5 |

3. See IBRD, *Price Forecasts for Major Primary Commodities*, July 1975, Table 20, p. 36. The price elasticity of demand was translated into a score using the following conversion scale:

| Score: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Price elasticity: | 1.5 | 1.2 | 0.95 | 0.8 | 0.65 | 0.5 | 0.35 | 0.2 | 0.1 | 0.05 |

4. Guesstimates based on writer's knowledge of production technology, and world production patterns. High scores correspond with low elasticity of supply in DME's.
5. Estimates of concentration and dispersion of importers. High scores indicate broad dispersion; low scores, concentration.
6. Estimates based upon knowledge of the commodity and scrap markets. Low scores indicate the presence of scrap markets; high scores indicate that the product is destroyed in the act of consumption.
7. Estimates based on knowledge of major LDC exporters.
8. Estimates based on knowledge of producing/exporting countries.
9. Estimates based on knowledge of international commodity markets. High scores indicate oligopolistic concentration among MNC's rather than more competitive conditions with arm's length buying.

**Table 10. Mineral procurement security policies of some major industrial countries**

| | Japan | France | West Germany | United States |
|---|---|---|---|---|
| Stimulation of domestic production (subsidized loans for exploration and mine development, state enterprise involvement) | Central coordination and funding of exploration (under the Metal Mining Agency of Japan: MMAJ) | Major effort by Bureau de Recherche Géologiques et Minières (BRGM) | Subsidized exploration loans (55 projects in 1979; 10 previous projects in operation) | — |
| Raw material economizing and recycling | Some R&D funding | Major R&D Subsidization; Assistance for specific investments (economizing) | Some R&D funding | Major R&D thrust |
| Assistance for overseas exploration and mine development | Public enterprise subsidized loans. Loan guarantees for mine development | Public enterprise involvement (SEREM) | Investment guarantee scheme (re "political risk") | — |
| Insurance for overseas investments | | Overseas Investment Insurance Scheme | Overseas Investment Insurance Scheme | Overseas Private Investment Corporation |
| Advantageous tax treatment | Some tax concessions for overseas ventures and long-term contracting | Normal tax treatment for mineral sector; one special depletion allowance | No special tax treatment | Depletion allowance on foreign orebodies worked by U.S. MNC |
| Public stockpiling policies | Nonstrategic, pro-stabilization stocks; subsidized loans for private stocks | Major expansion of government stockpiles under way; $U.S.600 million target | Program aimed at minerals produced in South Africa. $U.S.280 million subsidy to private stockholding | Major program (valued at $14 billion, May 1980) |
| Procurement "tie-ins" | Buy-back provisions for assisted projects | — | — | — |

SOURCES: P.C.F. Crowson, *The National Mineral Policies of Germany, France and Japan*, Mining Magazine, June 1980; and W.C. Chambers and J.S. Reid, *Canadian Resource Management and the North-South Dialogue*, Centre for Resource Studies, Queen's University, Kingston, 1978; and other fragmentary sources.

## Deep-Sea Mining

It has been widely feared that mining of deep-sea nodules would pose a threat to Canadian land-based producers of nickel and, to a much lesser extent, copper and cobalt. However, the technology for full-scale extraction of nodules is not yet completely proven, and massive R&D expenditures are still required. The economic feasibility of commercial extraction in the absence of massive subsidization is poor, and was further worsened by the last round of oil-price increases. (The extraction of metals from the nodules is energy intensive, compared to treating the sulphide ores of the Sudbury basin.) Only very large price increases for nickel,

manganese, cobalt and copper would make such deep-sea mining commercially viable — increases that would have to exceed those projected by forecasts for 1990 (Table 3).

The threat to Canada from deep-sea mining, therefore, lies not in any inherent competitiveness but rather in the possibility — indeed, the probability — that the major countries involved might provide massive direct subsidization, tax exemptions or preferential trade treatment to corporate consortia undertaking the mining ventures, creating unfair competition for Canada's land-based producers.

In this context, Canada and other land-based producers have looked for measures to protect their land-based industry from disruption by uneconomic measures. Canada was successful in improving a formula introduced into the Law of the Sea negotiations by the U.S. and Latin American copper producers that will limit the production of minerals from the seabed during an interim period so as to phase in seabed mineral supplies. However, it is recognized that the formula does not offer complete protection, particularly in periods of low market growth. Canada, therefore, has continued to work with other land-based producers to increase the protection offered to producers by means of an antisubsidization clause directed to seabed production, and a market access clause, to ensure against discrimination of land-based mineral production in consuming countries. The attempts to include an antisubsidization clause in the text have, to date, been opposed by the major consuming states and, particularly, by the EEC. A market access clause has been inserted in the negotiating text, but it is purely hortatory.

In 1980 the United States adopted interim seabed mining legislation, which provides for the issuance of permits for exploration and commercial exploitation of the deep seabed. West Germany, the United Kingdom and France followed suit in 1981. These actions are viewed as incompatible with the draft *Law of the Sea Convention* by the majority of states, and they threaten land-based producers with the possibility of uncontrolled seabed production should these countries stay out of the international Law of the Sea regime.

The Eleventh Session of the Law of the Sea Conference should be the final negotiating one, despite U.S. attempts to revise certain aspects of the deep seabed mining regime. Canada should continue its efforts to protect its land-based industry through the maintenance in the negotiating text of a production control formula and through attempts to include meaningful antisubsidization and market access clauses.

## International Marketing: Alternative Approaches

To meet the marketing challenges of the 1980s that have been identified — to maintain dynamic and expanding markets within a more liberal international mineral trading regime — Canada will have to adopt a number of policy innovations and shifts of emphasis. This section outlines some of the major policy alternatives and discusses specific lines of action to further Canadian mineral marketing objectives.

As part of a review of Canadian trade policy, the possibility of bilateral trade negotiations should be considered to obtain access to markets abroad for more finished goods from Canada.

Under GATT rules, any tariff concessions obtained through bilateral bargaining must, under the Most Favoured Nation Clause, be extended to all other countries. Despite this, and given the importance and competitiveness of Canadian mining and semifabrication activities, aggressive marketing efforts could well secure good shares of such liberalized markets.

### Negotiating Strategies with Higher Income LDCs

Tariff negotiations between developed market economies are conducted on the basis of reciprocity. On the other hand, the principle behind much of the tariff negotiations between developed and developing countries has been *nonreciprocity*, as is the case with the General System

of Preferences. Canada, however, should continue to consider *reciprocal* bargaining with selected middle-income countries that are rapidly moving towards "developed-country" income levels (NICs) — and which are also emerging as major mineral importers. This could entail access to their markets for some of our exports, including fabricated mineral-bearing commodities, in exchange for reciprocal access to the Canadian market.

Also, because expanded "one-way" access to Canadian markets for the manufactured exports of higher-income LDCs generates major industrial adjustment problems within Canada, it is only fair to insist that such trading partners help alleviate this problem by improving market access for our exports. This is especially important in view of the very high levels of nominal tariffs facing Canadian processed mineral commodities in some of these markets.

Such reciprocity would be a preferable alternative to reliance on quantitative limitations against imports from developing countries. Both the higher income developing countries and Canada would experience net gains from such trade liberalization in the longer term.

Again, any tariff concessions obtained through bilateral negotiations would have to be multilateralized under GATT provisions. However, this should not deter Canada from striving to improve market access in the NICs for commodities of significant export interest to us in the NICs.

Thus, Canada could consider initiating action of a bilateral or perhaps multilateral character in order to reduce the extremely high levels of protection against mineral semimanufactures in some higher income LDCs or NICs.

In the ongoing efforts to design Canadian export strategies for major world market areas, due emphasis will be placed on mineral semimanufactures and their market-access problems.

## Changing International Arrangements Governing Minerals Trade

Canada's overall position on international commodity agreements for primary commodities, and on producers' associations or cartels, is sound and certainly appropriate when applied to minerals. On commodity agreements, the position is to examine price stabilization problems on a case-by-case basis, within the context of the long-run trend of commodity markets.

With respect to membership in cartels designed to raise price by restricting supply, the Canadian position is that cartel action in minerals would *not* be advisable — it would generate only short-term gains at the long-run cost of new market entrants, reduced market shares, probable lower prices and retaliation by importers. At the same time, circumstances can be envisaged in which some sort of internationally agreed "orderly marketing arrangement" might be appropriate — severe, continuous and abnormal price depression, or unfair competitive practices by importers.

Where producer associations are concerned only with information collection and dissemination, and market intelligence, and refrain from predatory cartel-like practices, Canadian membership might generate some benefits, such as improved information flows.

It is difficult to oppose the objective of major industrial countries to secure their supplies of mineral imports. Indeed, for the minerals Canada imports — bauxite, alumina, phosphates, tin and manganese — expanded production abroad, improved recycling, economies in use and stockpile policies would likely benefit Canada through reduced and possibly more stable prices. The threat to Canada arises from subsidization of producers in the importing countries, of developing-country producers (in the procurement networks of some major industrial countries), or of deep-sea mining enterprises. Such potential and in some cases actual subsidization bears careful scrutiny by Canada. Where it already exists, as with Japanese mining

enterprises and processors, multilateral action is necessary to eliminate it. Where such subsidization may become implicit, as with deep-sea mining, strong pre-emptive bargaining is necessary.

Canada, therefore, must continue to oppose the emergence, intensification and proliferation of unfair competitive practices inherent in subsidization of mineral production, both land-based and deep-sea, for mineral procurement security reasons.

## The Law of the Sea Negotiations

Negotiations on a new *Law of the Sea Convention* are likely to be concluded in 1982. The Draft Convention provides a certain degree of protection for the Canadian land-based nickel industry by limiting seabed production. Given the international competitiveness of Canadian industry, improved protection could be obtained through the maintenance of fair competitive practices and a liberal trading regime. Canada should, therefore, continue to advocate the inclusion in the Draft Convention of an antisubsidization clause and free market clauses.

## Minerals as Aid—Potash

It has been suggested that Canada, with the most extensive known deposits of potash in the world, could provide this mineral to needy countries as part of its international aid program. As one of the principal ingredients in agricultural fertilizer, potash would seem to be a superior form of aid than food, as it could augment a hungry country's capability to grow its own produce. This view is strengthened by the fact that continuing food aid in some cases has depressed local farm prices, reducing incentives for local production and making the aid effort somewhat self-defeating.

However, there are some complications in effectively using potash as aid. First, food output would not likely increase if potash alone were made freely available to the neediest countries — the fertilizers required for most nutrient-depleted soils also must include phosphate and nitrogen. If these components were not also provided, the free availability of potash would have little overall effect on fertilizer use, unless the foreign exchange made available by the provision of potash was dedicated to the purchase of phosphate and nitrogen.

Furthermore, whether potash as aid would actually increase food production depends on how the aid is dispensed by the recipient government. If the price of fertilizer is in fact reduced in response to the provision of potash, the use of fertilizer could be expected to increase and food production should rise. But if the price of fertilizer is not reduced the potash aid would have been used, in effect, simply to increase public revenues, which may or may not be applied to food production or acquisition.

Again, potash as aid cannot replace food aid because the latter is, and should be, provided for emergency relief purposes, rather than on a permanent and continuing basis. Potash, on the other hand, could rarely be useful in emergencies, but would have to be made available over substantial periods of time and with substantial security of supply in order to help raise food production.

Potash aid also might merely support a country's balance of payments if the foreign exchange made available were expended on all other possible imports, and if the potash aid merely substituted for previous import purchases. If generalized support were a main objective of aid, then the provision of potash specifically is questionable.

In addition, a dilemma exists in attempting to help LDCs by providing potash aid. When potash prices are high and demand is tight, the potash industry has little ability to produce more potash, but this is when aid for the LDCs is most needed. When prices are low, assistance for potash purchases by LDCs is least needed, but increased sales may be important for the producer. In other words, the commercial and aid objectives are less complementary than might first be supposed.

There may be circumstances when commodity assistance to certain potash purchasers is appropriate. Precisely when prices are high, some type of temporary subsidization for the neediest purchasers would help ensure uninterrupted supplies at a reasonable price. In other circumstances and for some LDCs, longer term commitments to provide free or subsidized potash might be worked into their rural development and agricultural production program and Canada's assistance program, in order to raise food output for local and perhaps foreign markets. Ultimately, such assistance should help generate the country's capability to purchase potash fertilizers itself.

In all cases, however, potash should be provided as aid only within the context of the LDC's overall development priorities and its weighing of aid in commodity form rather than project or program assistance.

In summary, although the potential is limited, potash might be provided as a form of commodity aid. Aid in this form would have to be applied very selectively and carefully if it is to have a positive prodevelopmental impact, and if it is to be as useful to the recipient as forms of aid that are oriented towards the construction and operation of projects, or of programs. Current areas of technical assistance provided by Canada to the Third World, for surveys, mapping and exploration, should be continued. Other areas suitable for technical assistance should be examined.

## Conclusion

The Canadian nonfuel mineral industry will continue to remain highly dependent upon world market forces determined outside Canada. While little can be done by the Canadian government to influence economic growth rates in Canada's major markets, the federal government will continue to have an important role to play in international trade policy, in order to take better advantage of future opportunities arising from changes in mineral market structures, and in order to address problems of tariff and nontariff barriers and other "market distortions" that inhibit the upgrading of mineral resources in Canada. These trade issues will be addressed in the context of the federal government's policies for *Economic Development in the 1980s* announced in the Federal Budget of November 12, 1981.